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### ADDRESS OF THE PRESIDENT

#### A CONSIDERATION OF CERTAIN FEATURES OF PRESENT MEDICAL EDUCATION AND MEDICAL ETHICS

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ONE of the most urgent problems at this time, in need of prompt solution, is to determine in what way adequate medical care can be provided for those rural communities in which recent graduates in medicine are loath to take the places of those who have reached the end of their professional career. Economically, such an unfortunate condition forebodes disaster, for successful agriculture is a national necessity and proper medical care is as essential to the farmer and his family as are suitable educational opportunities for his children.

That the type of present medical education is at least in part accountable for the dwindling numbers of country practitioners is doubtless the case. A college degree followed by four years in a medical school and two years as a resident in a hospital requires an expenditure of from ten to fifteen thousand dollars. In seeking a proportionate return from the investment of that amount of capital a thickly populated district, in which hospital facilities may be found, is naturally chosen by the young graduate, and outlying sections are supplied by those who have failed to secure a foothold in a metropolitan centre. The considerable expenditure in time and money in acquiring a medical education is not the sole cause, however, of the dearth of the general practitioner. A scarcely less important factor is the development and popularity of the specialist. During the past generation this group, rapidly increasing in number, which necessarily crowds the cities, has been stimulated by the equally rapid advance in medical science, by the present methods of medical education, and to a considerable extent by the public demand. Instruction designed to prepare a student for the duties of a general practitioner has been submerged by undue attention and emphasis to the group of specialties in which the possibility of lucrative financial return and the opportunity to achieve professional success so strongly appeal to the undergraduate that the funda-

mental truths and true foundation of a medical education are frequently slighted. The fact that, in spite of the wide expanse of medical knowledge, the education of the general practitioner is still possible, cannot be too strongly emphasized.

The actual difficulty in making a living has made a country practice unattractive. Owing to the development of preventive medicine and district nursing, as well as to the improvement in hygiene and the organization of state laboratories, illness has become less frequent and the annual income of the physician is still further reduced by the fact that the automobile has made the specialist and hospital in the nearest city accessible to the well-to-do.

That this unfortunate state of affairs should be corrected, if possible, is self-evident. An increase alone of medical graduates would probably prove futile, for of those who fail to secure a livelihood in the city, only a part drift into the country, the remainder either seeking some form of institutional employment or withdrawing entirely from the practice of medicine to some more lucrative occupation. A radical modification of the preliminary course of study, as well as of the medical curriculum itself, has been suggested. That a preliminary college education is not indispensable has been proved by the distinguished career of more than one member of this association; while a considerable number of its senior members who completed their medical education in three years or less, have achieved noteworthy success and have made valuable contributions to surgical science. In those days the rapid expanse of surgery resulting from the discovery of Lister and the application of aseptic methods emphasized the shortcomings of their medical education and stimulated them to the acquisition of knowledge that only earnest and intensive study, continued over a long period of years, could supply. Whether the present graduate is similarly inspired is questionable. Perhaps the stimulation is less and the tendency to specialize concentrates their efforts to a single field, thereby dwarfing a broad foundation and possibly restricting any impulse to advance the science of medicine.

That the present medical curriculum could be extensively modified goes without saying. The early introduction of clinical instruction in both the hospital and dispensary could follow a relatively short period devoted to the study of elementary subjects, carried on chiefly in the high school, while laboratory courses could be largely curtailed. Graduates of such a course, supplemented by a modest experience as residents in a general hospital, would be qualified for routine general practice, especially with the coöperation and use of State laboratories and the advice of accessible consultants in difficult or intractable cases. That the intelligent high-school student is capable of acquiring a useful and practical knowledge of a clinical medical subject was demonstrated in an interesting way during the World War. One instance will suffice:

From the enlisted personnel of an evacuation hospital a restricted number of those who had had a partial or complete high-school training received theoretical instruction in the subject of anæsthesia and witnessed the administration of a general anæsthetic in



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a limited number of cases. Subsequently in the Argonne campaign the members of this same group gave the anæsthetic to a large number of patients without an anæsthetic accident. While they enjoyed the advantage of anæsthetizing healthy young subjects, the fact that many operations were done in a condition of shock, or after extensive loss of blood, materially increased the anæsthetic risk. It is of interest to note that several of these anæsthetists studied medicine at the conclusion of the war and are now successful practitioners.

The desirability of such a modification of the medical curriculum as suggested is certainly questionable. Even if distinguished by the award of a lesser degree from graduates of standard schools (and in no wise is the suspension of the standard schools advocated) it is extremely doubtful that graduates of the shorter or clinical course would be content with the lot of a rural practitioner, and it is probable that they would compete actively and not unsuccessfully with physicians in metropolitan centres, the specialist included.

As a possible solution of this interesting problem the organization of small, modest county hospitals is earnestly suggested. Several such units have already been successfully established by private foundation in scattered communities. They have quickly enlisted local enthusiastic support, have grown in size and influence, and have proved of the greatest benefit to the health and welfare of the section they serve. Hospitals equipped at the start with the fundamental requirements for the care of the acutely ill afford a nucleus for medical research and attract ambitious and skilful recent graduates. In the State of New York it is said that communities in which a hospital has been established show no diminution in the number of physicians and in some instances an actual increase is noted. If the organization of such a hospital proves too great a burden for the community to shoulder, it should be established by an endowment of sufficient size to include a fixed salary for its chief medical officer. Such endowments ought not to be difficult to secure from those who recently have contributed in such lavish fashion to the endowment of universities and charitable institutions. Independent of political control, hospitals of this character would quickly become active medical centres of the respective counties or districts in which graduate instruction by invited guests could be given not only in such subjects as preventive medicine, hygiene, serum therapy, etc., but in the equally important clinical subjects of medicine and surgery as well. It will be interesting in this connection to learn in what way the endowment fund at present being raised by the Albany Medical School will be applied to improve the medical standard of the rural practitioner. It is to be hoped that some plan will be devised that will provide practical medical instruction without material interruption of the physician's daily routine, since instruction of this type would prove much more valuable than the instruction given in the post-graduate schools of large cities, which is often inadequate in character and scope.

It is not intended in suggesting a possible modification of the present curriculum of the best medical schools of this country to lower their standards. The progress and development of the science of medicine can only be maintained by institutions of the highest class. It is simply a misfortune, if

not an actual sacrifice exacted of physicians at the present time, that the opportunity to earn a competence should be so long deferred. Not only must the high standard be maintained but constant effort must be made to detect and correct possible defects.

A still greater sacrifice is made by those who supplement their medical education by a service of several years' duration in hospitals of established reputation. Except for those of independent means the fourth decade is well advanced before those who follow this course can afford to establish a home and family. The opportunities, both clinical and in the department of research, that such a course affords are unrivaled. Perhaps the best results are obtained when such a course is divided between several rather than taken in a single hospital. In the former event it is of advantage if, at least in one of the hospitals, the incumbent is brought more or less into contact with undergraduate medical instruction.

The reputation of a medical school is made by its graduates. Its aim should be not only to prepare students for the practice of medicine, but also to provide opportunity in its laboratories and clinics for the training of teachers, not so much to fill vacancies in its own faculty, for too much inbreeding is not a source of strength, as to supply efficient teachers for the staffs of sister institutions.

The reputation of a medical school, as is the case with universities in general, is reflected in a measure by the geographical distribution of its students. Medical schools in which a majority of the States are represented on its roster enjoy a more envied reputation than those in which the larger number of its students come from adjacent communities.

In the conduct of the curriculum endeavor should be made to eliminate individual as well as departmental weaknesses. A member of the examining committee in a popular hospital of New York, over a score of years ago, comparing the candidates for the position of resident from two rival medical schools stated that, while in the clinical examination of either a medical or surgical condition there was little difference in skill, there was the greatest difference in their knowledge of anatomy and pathology; in the former subject the students of one of the schools were proficient, and in the latter subject the students of the rival school excelled. It was evident that a weakness in the curriculum existed in either school, and yet in neither was any change made in the conduct of the department in question.

More recently, in the World War the lack of adequate training in anatomy was very apparent. The débridement of wounds without needless sacrifice of nervous and vascular structures, the identification of divided tendons and motor nerve trunks required an anatomical knowledge which was often deficient. In the field and evacuation hospitals the anatomical surgeon, so frequently the object of sneering criticism in civil practice, came into his own.

The lack of a proper foundation, moreover, is frequently shown in civil practice. In student instruction there has been a tendency to supersede former methods of examination and diagnosis by the application of the X-ray. In

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dislocations, in obscure fractures in the vicinity of joints, in the diagnosis of thoracic and abdominal conditions, the interpretation of the radiogram is unduly emphasized in entire disregard of the fact that, later on, in actual practice, this most valuable method of diagnosis may not be available. It is a safe maxim to enforce that, in undergraduate instruction the result of X-ray examination should be utilized only after every effort has been made to establish the diagnosis without its assistance.

The advisability of compulsory attendance in student classes is very doubtful. Essential as it is in the preliminary school or college, such a policy seems unnecessary if not actually unwise, in professional schools in which students are investing their capital in preparation for a future livelihood. The extent of attendance, if voluntary, is in direct ratio to the value of the instruction given and is a reliable index of the teaching ability of the various members of the staff. Every professional school should aim to develop a student body, homogeneous, enthusiastic, eager to acquire knowledge and to teach each other, imbued with a spirit of friendly competition. There is no place for the drone, the lazy individual, or for those whose heart is not in their work. If students are carefully selected preliminary examinations will quickly winnow the wheat from the chaff and rigid final examination will determine the fitness of the candidate for the practice of his profession.

To detect and to correct the defects of a medical curriculum presents many difficulties. For this purpose, if properly utilized, the recent graduate is, it is believed, peculiarly qualified to give valuable assistance. Of late, a number of recent graduates of schools in Canada and of this country were requested to suggest modifications in undergraduate instruction in Anatomy and Surgery. Their replies were most interesting and while details need not be given, they suggested changes in the length and character of the instruction in anatomy, stressing the value of early demonstrations of the clinical features of simple uncomplicated fractures in connection with the study of osteology. They emphasized the value of animal surgery in the teaching of aseptic technic, suggesting that more time be devoted to this subject. Instruction in gross pathology and instruction in operative surgery on the cadaver were considered inadequate and attention was called to the almost complete lack of practical instruction in the administration of general anæsthetics. The contrast between the heads of two departments in which the instruction of one was compared to a bag of wind and of no value while the instruction of the other was said to have the merit of making the subject both interesting and comprehensive, was striking to say the least. In short, the comments were of such a nature as to warrant the conclusion that occasional conferences between suitable committees of the Faculty and recent graduates would prove of great value.

In the consideration of certain ethical standards so much attention has been given to the subject of commercialism in medicine that little need be added at this time. In the legal profession profit sharing is carried on with the full approval of lawyer and client. In medicine an analogous custom has

never been sanctioned. In many instances the compensation of the attending physician is doubtless disproportionate to that of the consultant to whose care the patient is consigned. A satisfactory adjustment has hitherto proved impossible. Secret division of the spoils cannot be too emphatically condemned. The undoubted increase of this pernicious custom demands some solution that can be reached only after a careful and exhaustive discussion in which both the layman and physician shall participate, and of which the result shall have the approval of the public at large.

One of the most invidious forms of this spirit of commercialism is the sordid avarice reflected in exorbitant charges for services rendered patients of modest means. The demand for the major portion of the annual wage or income of one of these victims transgresses every tradition of the medical profession. The spirit of kindness, of helpfulness, of sympathy, the satisfaction of restoring health and happiness without thought of compensation, in short, "All the gentler morals such as sway through life's more cultured walks and charm the way," are completely ignored. Unfortunately instances of this species of extortion are not rare and every effort should be made to eradicate this despicable evil.

Another species of fraud is practiced by the physician who, when a consultation is requested, introduces a colleague no more skilled than himself as the "specialist or professor", with whom the consultation fee is shared. These wolves in sheep's clothing do not hesitate to fatten on the scanty earnings of the honest laborer. Similarly guilty is the physician that, for a pittance, provides the plaintiff or his lawyer with a certificate alleging injuries that were never received. Such a certificate was recently presented to the adjuster of a local railroad company several days after an accident in which not even the slightest scratch was visible. During the past year the names of a number of physicians guilty of a similar offense were published in the daily press in connection with an investigation of the ambulance-chasing evil.

Equally lacking in honesty is the X-ray expert who testifies under oath to a false interpretation of radiograms for the benefit of the plaintiff in accident litigation. Perhaps the most striking instance of stultification on the part of an expert witness occurred recently, in which an increase in intracranial pressure from the effects of a head injury was claimed by the plaintiff. The request of the defendant for a spinal puncture was denied by the court after the presentation of an affidavit in which the plaintiff described the extreme torture to which he had been subjected by the spinal puncture as carried out by the testifying expert. He stated that during the operation his neck and spinal column were forcibly flexed on his thighs and abdomen while his neck was so tightly constricted by the hands of an assistant as to cause a sense of suffocation. These measures, it is well known, increase temporarily the normal intra-cranial pressure. The agony was such as to make him most unwilling to submit to a repetition of the operation.

It is not unnatural to assume that the physicians referred to in these various misdemeanors lacked both educational and moral training. It is unfor-



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tunate to be obliged to state, however, that in more than one instance the guilty party was a graduate in both arts and medicine of one of our oldest universities.

In what way, if any, is either the subject of medical education or that of medical ethics the concern of members of this association? No body of men is better qualified to influence the development and conduct of our medical schools. Not only skilled in the practice of surgery but also in the art of teaching, the members of this association, in many instance represented on the faculties of long-established medical schools of the highest reputation, are peculiarly qualified in view of their experience to consider the wisdom of any change in either the character or length of a medical curriculum. By you the problem of how to provide rural communities with efficient medical attention must be solved—whether by the shortening of the period of preliminary education, or by some change in the medical curriculum, or perhaps by the organization and endowment of county or rural hospitals; if you believe the latter course desirable the application of the remedy will be undertaken by the lay public only after being assured of your approval and willing coöperation.

Of greater power, if possible, is your influence in medical ethics. Legislation or the action of official societies are of little avail without the earnest support and sympathy of the leaders of the medical profession. Their combined action is essential if satisfactory progress is to be made. No profession is without its black sheep. The ideal can never be attained, but the endeavor to approach it must never be relaxed. You are frequently consulted in regard to the choice of a profession. Your example and success constantly attract the ambitious to attempt to follow in your footsteps. It is only by continually striving to enlist students with the highest motives in the profession of medicine that its lofty humanitarian standards can be maintained and developed. To endeavor to place the science of surgery on a continually higher plane, no less than to contribute to its actual scientific advance must be the goal of every member of this association. May it carry the torch of progress ever forward in the future as in the past. Long live the American Surgical Association!

## THE SMALL HOSPITAL-MEDICAL SCHOOL IN AMERICAN MEDICAL EDUCATION—IS THERE A PLACE FOR IT?

By ARTHUR W. ELTING, M.D.

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IT is a reasonable presumption that the members of the American Surgical Association are deeply interested in the problems of medical education especially as they are related to the active practice of medicine. It seems, therefore, opportune that we contemplate for a few moments the trends of medical education in America and consider whether the results and the prospects are the best attainable from the standpoint of both the profession and the laity.

During the past two or three decades great changes have occurred in the principles and methods of the conduct of all industrial, commercial and financial enterprises. Larger and larger combinations have been effected with a conclusive demonstration of the greater productive and financial efficiency of those combinations than that of the smaller competing units. The result has been that the smaller unit is gradually disappearing and is being merged with the larger. Huge combinations of financial, mercantile and industrial enterprises are the fashion of our time, and still greater ones are in prospect. It is but natural that with the business world thus imbued with enthusiasm for such huge combinations, these successful men as trustees and governors of our educational institutions should feel that the same principles which have come to govern business in general should direct the trend of modern education, and inasmuch as these same successful men have furnished and are furnishing much of the money to maintain our educational institutions, it is but natural that they should have a very important voice and vote in determining many of the methods.

It has become a very popular theme to emphasize and advertise the large amounts of capital devoted to education, sometimes to the detriment of a careful consideration of the products of the so-called education. There is an increasing tendency today to rate educational institutions on the basis of their magnificent buildings and huge endowments rather than on the quality of the product they produce.

It is furthermore, a well-established fact that in all large aggregations of capital or education, the individual becomes submerged.

It is quite evident that in the minds of some at least of those responsible for our educational institutions, there has arisen the feeling that these institutions have grown too large and that mass production which has been such a great boon to industry can scarcely be considered a boon to education. An effort is now being made to discover some solution of this problem, and, in fact, some of our oldest and most famous institutions are embarking upon a plan to organize several smaller divisions or colleges within the larger one

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in order that the student may be considered more as an individual with an opportunity to remain such rather than become a standardized product.

What is true of education in general is also true of medical education. From a period when there were too many medical schools of low attainment we have gradually passed to a period when we may possibly have too few and when most of those have grown too large. The tendency latterly has been to confine our medical schools chiefly to the largest centres of population and to emphasize the importance and necessity of large physical and financial structures. Many of our profession view with concern for both present and future the trend toward the development of huge institutions for the teaching and practice of medicine. Granted that this development has demonstrated its value in some ways, is there not a place for the smaller medical school which takes into consideration the needs of the community and of humanity?

Medical education has become a very expensive procedure when it costs an institution from two to three thousand dollars a year to educate a single student to which must be added the cost of the student's maintenance in our larger and more expensive cities. This fact alone makes it impossible for many promising young men to enter the profession, men of the type who, judged by the past, would be among the profession's best assets for the future.

Some of those in the forefront of the direction of medical education do not seem to fully realize that the first and chief duty of a medical school is to educate and prepare doctors to care for the sick and not to make as the chief object of medical education the production of so-called scientific investigators. The scientific investigator is and should be the by-product of medical education and not the goal. Best of all is that type of medical education which recognizes the important relationship of science as the foundation and background for medical practice.

It is unfortunate but in some instances true that the size of the budget of some medical schools bulks larger than the quality of the product or service to humanity.

In medical as perhaps in no other form of education, contacts are of the greatest importance—contacts with patient and teacher. We can all of us count on our fingers the few great teachers we have had and we all realize that we have been much more influenced by the personal contact at the bedside or in an operating or autopsy room than in the more formal setting of a class room. It is in the smaller medical schools that such intimacy of contact can be had to the best advantage. Many of our medical schools have started with or adopted the idea of small classes, but have found it very difficult to continue this policy because of the pressure of prospective students and the size of the plant and endowment. It is furthermore a fact that the burdens and responsibilities of the conduct of a clinical department of a large medical school are so great that little time is left for the head of the department to perfect himself in the art of clinical teaching.

The history of medical education amply justifies the contention that small medical schools of the highest type can be successfully maintained in the smaller cities where it is possible for the medical school to be an integral part of a university and of an adequate hospital, both of which are absolutely essential for the maintenance of a medical school of the proper standards. One need only cite the hospital-medical schools of Great Britain and of the Continent to amply illustrate and demonstrate this contention. Many such opportunities are presented in this country with one of which the writer has been associated for thirty years.

Fourteen years ago the Albany Medical School was reorganized and made an integral part of Union University. A definite plan was formulated, one of the chief factors of which was that it must be and remain a small school, the senior class of which should never number more than twenty-five or thirty students. From thirty-five to forty are admitted after careful inspection and selection and these are gradually reduced in the first two years to twenty-five or thirty. In this way intimacy of contact with teacher and patient is assured. In admitting students, preference is always given, other things being equal, to those from the surrounding territory. The large majority of the students thus come from a radius of 100 miles and many young men of small means are enabled to secure a medical education at a relatively small expense, many of whom are in part or whole self-supporting. Had it been necessary for these men to go to our larger institutions in the large cities, medical education would have been out of the question.

The principle was firmly established that the essential aim of the Albany Medical School was to serve the surrounding territory; first, in providing an opportunity for the right kind of man to secure an adequate medical education; and secondly, in endeavoring to influence him in later life to help in the service of that territory. When young men come from the country or a small town to a small medical school in a relatively small city, they are much more inclined to remain in that general vicinity than they are after four or more years in the white lights of a large city where the very air is polluted with commercialism. From such a small medical school comes a greater tendency to the practice of medicine and less of an one toward specialism, which is today one of the serious problems of medicine.

Gradually the physical equipment of the Albany Medical School and the Albany Hospital were merged until finally there resulted a medical school physically a part of the hospital with the establishment of the hospital on a full university basis of such a nature that every member of the teaching staff of the medical school occupies a corresponding position in the hospital. By providing hospital staff positions for the heads of the departments of anatomy, chemistry, physiology and pathology a twofold end was attained. The heads of these departments were forced more and more into clinical contacts and the students obtained a better appreciation of the relationship of the so-called scientific branches to the clinical and a better understanding of the practical utility of scientific measures as well as a realization



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of the fact that science should in the last analysis serve man. The presence of the physiologist with the electrocardiograph at the bedside of a cardiac case is a much more impressive laboratory experiment than one conducted in the laboratory.

All the members of the clinical staff actively participate in the community life, making the hospital-medical school their chief responsibility. Thus was evolved what has been called the hospital-medical school on a university basis.

The problem of so-called rural medicine has long been recognized as an important one toward the solution of which the small medical school should especially devote its attention. To this end there has been evolved by the Albany Medical School a so-called five-point program as follows:

1. By giving preference in the selection of medical students to those whose affiliations are in its district.
2. By primarily training students for general practice and properly fitting them at moderate cost for such work.
3. By providing its graduates and other hospital internes with data concerning opportunities and locations where doctors are needed.
4. By coöperating with graduates and other physicians in the large district served by the school, giving them an opportunity to take graduate work, review and advanced courses, either formally or informally, as well as special work in all departments of the medical school.
5. By suitable publicity, informing rural communities of the advantage of employing their local doctor who can care adequately for more than 90 per cent. of their ills, and whose coöperation and interest is of the greatest importance in the care of the remaining 10 per cent.

One of the most important features of this program is the maintenance of a liaison department between the hospital-medical school, other hospitals, the profession, public-health workers, and those responsible for the sick poor of the surrounding territory. Such a department functions all the while and in an impartial and humanitarian manner, thus avoiding the temptation and criticism of commercialism. In this way it is possible to establish and maintain a relationship between the man in rural practice and an institution rather than with an individual; and an institution which functions at all times for the benefit of both patient and doctor.

Great benefits accrue to a hospital from such an association with a medical school, for it becomes possible to render service of a character that could only be had in the most heavily endowed institutions and even then it would be less efficient because of the absence of the teaching spirit. From an economic standpoint, there can be no question but that the hospital-medical school is far more efficient than any combination or relationship so far devised. By thus improving the quality and scope of the service and reducing the cost, the hospital-medical school renders the greatest possible service to the community and helps in every way to maintain the highest standards of professional excellence. The intimate personal contact of the members of the staff, both pre-clinical and clinical, reduces friction between individuals and

between departments and develops a spirit of coöperation which is of great benefit to teacher, student and patient.

As to the practical results obtained in carrying on a small medical school, a brief review of the past fourteen years since the reorganization may not be out of place. Due to the splendid management of the dean, Dr. Thomas Ordway, and the unselfish coöperation of the faculty, the budget for the entire conduct of the school in the first five years was between \$35,000 and \$40,000 a year, and since then as more funds became available, it has been gradually increased to \$90,000 a year. This has made the cost per student about \$800 per year as compared with two to three thousand per year in many of the larger schools. The tuition of \$300 per year has been kept low in order to place the school within the means of promising young men of limited resources. At the present time there are 122 students in the school enrolled as follows: First year, 41; second year, 35; third year, 22; fourth year, 24.

During the fourteen years 324 men have been graduated and of those educated since the reorganization, only one has failed in any final state or national board examination, and in that instance in only one subject. Of the 277 graduating during the first twelve years since the reorganization, 1915-1926, 153 or 56 per cent. have settled in what is regarded as the area which the medical school serves, which is approximately 150 by 90 miles in extent. Those graduating in the past two years are as yet not definitely enough located to be statistically included.

As the aims of the medical school have become better understood and as greater influence has been exerted on the students and graduates, the percentage of the last three classes locating in this immediate territory has risen to 72 per cent.

For the past nine years, in coöperation with the New York State Department of Health, a course in Infectious Diseases and Public Health has been given each year. To this course have been added numerous clinical subjects treated from the more recent points of view and emphasizing advances in various phases of medicine. This course has been taken by about 250 health officers and other physicians.

A careful census of the physicians in the territory served by the Albany Medical School and embracing a population of well over a million shows that more than 50 per cent. of the physicians practicing in that area are graduates of the Albany Medical School, thus demonstrating the validity of the theory that men who come to the school from that general territory are more apt to locate within the territory and thus provide a substantial basis for some solution of the problem of rural medicine as well as the importance of training men to be practicing physicians rather than scientists or specialists.

The Albany Medical School was among the first to adopt the plan of a reserve training course as outlined by the surgeon general and one of the first to graduate young men into that corps.

From this brief survey of the trend and cost of medical education and fourteen years' experience in the conduct of a small and inexpensive medical

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school, it would appear that there is not only a place but a decided need for the small hospital-medical school, which can be maintained on the highest plane with the outlay of a comparatively small amount of money. It would further appear that such a hospital-medical school can be of the greatest assistance in the solution of the problem of rural medicine as well as the maintenance of the highest standards of medicine and service to the community.

Part of the duty and responsibility of the American Surgical Association is to train and inspire the next generation of doctors as our generation has been influenced and inspired by the outstanding figures of the past. Failure to do this may have resulted in developments of which we do not fully approve, but for which we are indirectly responsible because of our failure to actively participate.

DISCUSSION: DR. JOHN A. HARTWELL, of New York City, remarked that he had had an opportunity recently to sit on a committee in connection with the New York Academy of Medicine, which studied the question of the medical profession's attitude toward the community, a point that Doctor Eliot had brought out very forcibly, and one which Doctor Elting touched upon when he said those who were in the community of which I happen to be a member suffered from the commercial pollution of the atmosphere. That is a gentle impeachment that, to a very great extent, has to be recognized.

Feeling that the profession suffers from that, it has been faced with the problem of answering some of the questions which these two Fellows of the Association have put before it.

The study given this subject in this committee makes it clear that the only way this unfortunate commercial trend can be controlled is by the influence of the leaders in the profession. No code of ethics, no legislation, nothing except personal influence is going to have the desired effect. It is demonstrated that that personal influence must begin, as both the speakers have emphasized, in undergraduate training.

Much time is spent in providing these young men with a thorough training in scientific and clinical subjects, but very little in teaching them how to become practitioners of medicine in accordance with the highest traditions of the profession. They are left to acquire this by themselves without being given the benefit of the experience gained by the men in actual practice. That is not quite fair, because the moment they are thrown out on their own resources they come under influences that are exceedingly difficult to cope with.

There have been some very pathetic instances, in which it has been quite definitely demonstrated that an honest man, doing his best to make his way, has had to succumb to the situation that Doctor Eliot spoke of in the division of fees in one form or another; otherwise he could not compete with those in the community who are doing it.

DR. JOHN M. T. FINNEY, of Baltimore, Md., said that Doctors Eliot and Elting had dealt with a situation which everyone who is in active practice

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appreciates as really serious. The work that was headed by Mr. Flexner some years ago succeeded in closing up a good many medical schools. That was unquestionably good work which, however, did not prove an unmixed blessing.

If the profession does not accept its responsibility to take care of the sick of the country at large, it simply lets down the bars and opens wide the gates for the army of quacks of one sort or another.

One reason why there are so many of them is simply the lack of qualified practitioners in many parts of the country, and especially in the smaller towns. He felt that Doctor Elting in his paper had really offered a practical solution.

He was heartily in accord with the bulk of the President's address, but disagreed very sharply on one point, speaking from the standpoint of his own experience. He said that perhaps he understood him incorrectly to advocate the establishment of small hospitals in rural communities. His experience with such institutions, from a surgical standpoint, is that they are an abomination. They may be all right from a medical standpoint. But from the surgical standpoint it means just this, in the minds of the uninitiated, in the holy of holies of the modern operating room any surgical sin may be committed because in such surroundings, one can do no surgical wrong. He has seen much really bad surgery, and many poor results coming out of the small local hospitals performed by inexperienced operators with no adequate training and no surgical background.

DR. JOHN H. GIBBON, of Philadelphia, suggested in the theme discussed by Doctor Elting that this question can be met to some extent by the large medical schools, which are not doing their duty to the public if one takes into consideration their plants and their endowments. The classes have been reduced, the plants have been increased, the endowments have been increased and the product has been reduced.

He said: "A distinguished Frenchman came over here some years ago in order to investigate American medical education. I knew there would be little opportunity of getting a public expression of his real opinion, but I had an opportunity to become somewhat intimate with him. In a quiet talk I asked him what impression he had. I will not mention the name of the institution of which he spoke, but it was a highly endowed institution with a very complete hospital, laboratories, etc. He said, 'I will tell you one thing—I saw very few students. I asked them how many there were, and they told me there were about 300.' I inquired what he thought of that. 'I'll tell you if we had the same plant and the same endowment in Paris, we would teach 5000.'"

DR. ARTHUR D. BEVAN, of Chicago, Ill., said: "I would like to sound an optimistic note, a very optimistic note. We are doing so much better in medical education and in the practice of medicine in this country than we have ever done before that there is very little ground for pessimism.

"Great improvements were made by the medical profession itself long before we called on Mr. Flexner, and Mr. Pritchett of the Carnegie Foundation to help us in this work. Even before the Flexner report the American



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medical profession had reduced the number of medical schools in the country over 25 per cent., and within a few years it was reduced another 25 per cent. The medical school situation has been tremendously improved.

"We are developing good hospitals everywhere in this country. We have more than 6000 hospitals. I am surprised at the splendid work that is being done in the small hospital everywhere in the United States. Go to California, or Texas, or Minnesota, or New England, and inspect these hospitals. You will find the very best work being done everywhere, work that is needed. The small hospitals of the country are caring for emergency cases that could not be sent to the great city hospitals. Recognizing the improvements that are still ahead of us, we should feel most enthusiastic about the splendid progress that is being made and the splendid work that is being done."

## THE CAUSES OF FAILURE IN THE OPERATIVE TREATMENT OF CARCINOMA OF THE ŒSOPHAGUS

By FRANZ TOREK, M.D.

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THIS paper will deal only with carcinoma of the thoracic and abdominal portions of the œsophagus, not with carcinoma of the cervical portion, which has been repeatedly operated with success in accordance with fairly well-established modes of procedure and precautions against the incidence of mediastinitis, aspiration pneumonia, and secondary hæmorrhage.

*Statistical Data.*—Regarding the statistics on operation for carcinoma of the thoracic and abdominal portions of the œsophagus, it has been impossible for me to reach any conclusions on the percentage of successes and failures in the cases operated throughout the world, as the reports are too incomplete, and I am confining myself to data from the Lenox Hill Hospital of New York. As yet, the failures far outnumber the successes. In January, 1925, I published the data on the complete removal of the carcinomatous œsophagus from the thoracic cavity, the percentage of failures being 92.3 per cent. It has improved slightly, the total percentage of failures having been reduced to 91.2 per cent. Much of this unfavorable showing is due to our former eagerness to operate on every one of the rather limited number of patients at our disposal. With our present judgment, the procedure in a number of those then operated should have gone no further than the exploratory thoracotomy. But even with that allowance the percentage of operative recoveries would probably not have been a great deal higher, and so it behooves us to pass in review the main causes of failure and to offer suggestions for lessening the danger. In rehearsing the causes of death, however, I have to return to the literature, as many of those reported have not occurred in my own personal experience. From the published cases with disastrous outcome I have gleaned only a sufficient number to be representative of the difficulties encountered. In connection with some of these I have stated what corollaries should, in my estimation, be drawn from the experience; in others the lesson to be learnt was too evident to require mention.

*Hæmorrhage.*—Of hæmorrhage, which has been responsible for a number of deaths, Eduard Rehn describes two cases. In one, when performing the first stage of a two-stage extrapleural resection, he separated the tumor and wrapped it in iodoform gauze. The patient died on the second day from severe secondary hæmorrhage. The autopsy in that case also revealed metastasis in the regionary and epigastric lymph nodes and in the liver, which had not been suspected owing to the moderate extent of the lesion. The other case was one of death from hemothorax, in which atelectasis of the lung, due to compression, was found. It seems evident that in both of these

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cases the method of operation afforded too little space for safe hemostasis and, in the first case, also for the detection of metastases. The second case, in which the hemothorax caused atelectasis of the lung, might be cited as an argument in favor of drainage, but in my opinion it points more strongly to the desirability of an exposure sufficiently good to render accurate hemostasis possible, for prevention is better than cure.

Gauze tampon drainage, employed for hemostasis, has given rise to pneumothorax. To avoid this occurrence, Küttner and Lotheissen have led the gauze out through an oblique canal, piercing each subsequent layer one to one and one-half centimetres further away. The obliquity of the channel is claimed to prevent pneumothorax.

A patient operated by Zaaier died from hæmorrhage due to decubitus of the aorta. After decortication and collapse of the chest, according to his method, the upper stump of the oesophagus was displaced outwardly, crossing the aorta. The decubitus developed at the crossing point.

Dangerous and fatal hæmorrhage has occurred in the methods of removing the oesophagus without opening the thorax, *viz.*, separating the upper portion of the oesophagus by an approach from the neck and the lower portion by an approach from the abdomen, after which it is either removed by invagination or is released from its central thoracic attachments by tunneling with the aid of a blunt instrument. The ligation of vessels torn in either of these procedures is of course impossible. Failure to control hæmorrhage is largely due to insufficient exposure owing to the choice of a method that fails to afford ample access.

The presence of blood in the pleura is objectionable even if the amount is far too small to figure as a dangerous hæmorrhage. Allen (*Sur., Gyn. and Obstet.*, July, 1927), in a series of experiments on animals, has shown that it predisposes very strongly to the development of empyema, and he attributes this to the fact that the blood furnishes an excellent culture medium for the growth of microorganisms.

*Pneumothorax.*—Pneumothorax has caused death, especially in some cases of injury to the lung or bronchi, where there is a closed pneumothorax which steadily increases because of a valve action of the wound allowing air to enter but not to escape. Extrapleural attack, if performed without injury to the pleura, ought to safeguard against pneumothorax; nevertheless, cases of extrapleural resection have been reported in which death occurred on the day of the operation, ostensibly from pneumothorax. It must be assumed that the pleura was injured, an accident which not infrequently happens in extrapleural operations.

Pneumothorax has occurred even after completion of the operation and closure without drainage by the entrance of air between sutures at the chest or neck. Such occurrences emphasize the necessity of careful and accurate suturing. I have not seen a pneumothorax from this cause but have in one case experienced a leak occurring some days later owing to stitch infection.

If drainage is established, air may enter through the tube; however, the

occurrence of pneumothorax from that source may be avoided either by covering the drain extensively with rubber dam to prevent aspiration or by employing the method of tightly closed drainage, the end of the tube being immersed well beneath the level of a fluid in a bottle.

*Pleuritic exudate and infection of the Pleura.*—In transpleural operations the pleura is subjected to irritation by the necessary manipulations, resulting in an exudate of greater or less amount. Meyer reported a death on the second day from gradually increasing cyanosis, the autopsy showing compression of the lung by a serosanguineous exudate; in another fatal case the lung was compressed by fluid and air. On the other hand, the presence of an exudate may be of comparatively slight importance and be promptly absorbed, as I have had occasion to observe.

Of much more serious significance is the occurrence of infection of the pleura, especially that caused by rupture of the carcinoma, which, owing to its putrid character, soon leads to death. Even infection from injury to an uninvolved portion of the carcinomatous œsophagus is exceedingly virulent. In extrapleural operations this infection may be limited to the mediastinum, provided the pleura has escaped injury.

In the methods of removing the œsophagus without opening the thorax, either by invagination or by tunneling, already referred to under "Hæmorrhage," the œsophagus is apt to tear during the procedure, and the tear is most likely to occur at the site of the carcinoma. The result would be a putrid infection of the pleura or mediastinum.

Leakage from suture of the œsophagus, one of the outstanding sources of infection, has happened in all cases of blind closure of the upper stump after resection, although one of these, Bircher's case, held for six days. To lessen the danger of leakage where the stump of the œsophagus is united with the stomach, Bircher, in 1918, inserted the œsophagus into the stomach in a manner similar to that of the rubber tube in a Witzel gastrotomy, a method which was subsequently copied and modified by Kirschner and others.

Leakage and death following anastomosis with a Murphy button and other buttons have been reported by Tiegel, Sauerbruch, and others.

*Mediastinitis.*—The same causes that are active in bringing about infection of the pleura are also responsible for the occurrence of mediastinitis, which may occur alone or in combination with infection of the pleura. As an example of the former I would cite a case published by Neuhoff in which death occurred one week after the first stage of a two-stage extrapleural operation. The most likely cause of infection in that case would be an injury to the œsophagus.

As an instance of the much more frequently occurring combined infection of mediastinum and pleura I would mention a case from our hospital in which the autopsy revealed a round cauterized area on the posterior surface of the left lung, which in all probability must have been due to imperfect protection at the time when the œsophagus stump was cauterized.



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The result was an extensive mediastinal infection with purulent fluid in the posterior mediastinum and a thick greenish-yellow fibrinous exudate covering the bed of the removed oesophagus, the ascending aorta, the posterior surface of the pericardium, and the root of the left lung.

*Necrosis of the Cut End of the Oesophagus.*—Where end-to-end union was performed following resection, necrosis at the cut end was often found; the result of this was leakage, infection of the pleura or mediastinum, and death. In these cases the necrosis was probably due to tension on the sutures. However, necrosis at the cut end has also been occasionally observed in cases where the oesophagus was drawn out through the neck and placed antethoracically beneath the skin, according to my method. Here, where the element of tension was excluded, the localized necrosis was probably in part due to the extensive liberation of the oesophagus, to the detriment of its nutrition; possibly there may have been some pressure on the oesophagus where it passed down between the clavicle and the skin.

To meet this tendency to necrosis of the end of the stump it is advisable, first, to separate the oesophagus from its attachments no higher up than absolutely necessary; secondly, to make sure that in the newly established antethoracic tunnel the oesophagus is nowhere subjected to pressure endangering its circulation; and thirdly, to place the outlet of the subcutaneous tunnel sufficiently high to allow the oesophagus to protrude one or two centimetres, so that, if necrosis should result, it may take place outside of the body. Lotheissen's suggested procedure of inserting a small drain alongside the oesophagus would, it is true, anticipate the treatment of a possible phlegmon but may, on the other hand, help to induce pressure necrosis and may pave the way for a pneumothorax or mediastinal emphysema. I should therefore prefer not to employ it as a precautionary measure.

*Necrosis in the Course of the Uncut Oesophagus.*—Gangrene of the exposed part of the oesophagus causing mediastinitis and death has been reported by Lilienthal as occurring in two cases of two-stage extrapleural resection. A similar condition has been reported by Küttner.

*Pneumonia.*—Pneumonia as a cause of death has been reported a number of times. Of special interest in this connection is one of Sauerbruch's two cases of death from pneumonia, in which the autopsy showed that the oesophagus wound had completely healed.

*Diaphragmatic Hernia.*—Diaphragmatic hernia as a cause of death has been mentioned in cases where, subsequent to operations on the oesophagus and cardia, a gap in the diaphragm was either imperfectly closed or allowed to remain entirely open.

*Inanition.*—Inanition is a frequent cause of death in cases of carcinoma of the oesophagus where no operation is performed. Subsequent to resection of the carcinoma one would not expect inanition to appear as a cause of death. But it did happen in two of my own cases. The first of these was due to an unpardonable blunder. After the operation we found that only two or three ounces of food could be poured in through the stomach

tube, and even this amount did not remain inside. We were at that time very deeply interested in the study of the vagi and the effect of their division on the function of the stomach and tried in vain to explain this condition on the basis of some nerve influence, although it was not suggestive of the cardiospasm which might have been expected, till, at the end of the first week, it occurred to me to investigate whether possibly the tube was not in the stomach, and then only it turned out that an orderly, on getting the patient ready for operation, had accidentally pulled out the tube and, fearing a reprimand, had forcibly pushed it back into some pocket outside of the stomach newly made by his brutal and clumsy procedure. Its replacement now, however, did not save the patient, who died soon after, on the eighth day after operation, from inanition.

The second patient died a victim of his philosophy, for he refused to take food after the operation. On the third day, when I remonstrated with him on this matter, he declared that, although he appreciated what had been done for him, he had made up his mind that he did not wish to live, because he had learnt that his case was one of cancer and that cancer always recurred. He continued to refuse nourishment and died on the seventh day from inanition.

*Injury to the Vagus.*—The effect of injury to the vagus upon the heart has always been a matter of great interest, and the literature contains numerous observations varying from sudden death to complete absence of any effect on the heart or stomach. Thus, in most of the animal experiments, the bilateral division of the vagi above the diaphragm was well borne and did not cause subsequent cardiospasm. Of the cases that died directly from injury to the vagus I shall only mention two reported by Eduard Rehn. In one of these the division of the left vagus was made proximal to the place where the branches to the heart come off. In the other case the nerve had been cocainized and had been separated from the œsophagus without any inadvertent occurrence, but when it was pushed aside a second time, for the purpose of wrapping the tumor in iodoform gauze, the patient died suddenly. An observation like that shows how dangerous to life irritation of the vagus, or tugging at it, may be.

Eppinger and Hess have made researches on the tone of the vagus. From their observations it appears probable that persons who have a heightened irritability of the autonomic nervous system and an exaggerated sensibility to pilocarpin (excessive salivation, profuse sweating, retardation of the pulse), are also particularly sensitive to injury of the vagus. Some patients manifested sudden heart block, while others were not thus affected, although the operation was performed with equal care and caution. On the basis of these studies Eduard Rehn suggested testing patients as to the tonicity of their vagi and to administer atropin before operation in case the test is positive. Grave, of Moscow, who recommends the same thing, states that irritation of the terminal sensory vagus filaments in the lung causes disturbance of respiration if there is an open pneumothorax and that it also

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causes a "vagus pulse." The dogs manifested unsteadiness of the pulse wave in the pulmonary artery; after injection of atropin the pulse became steady again and somewhat more rapid. Grave therefore recommends the subcutaneous injection of one-half to one milligram of atropin before endothoracic operations on the basis that it is of advantage not only in reducing the secretion of saliva but also by stimulating the respiratory centre. This latter effect he considers important in case there is an excess of carbon dioxide; but herein he is probably mistaken, as carbon dioxide is itself a good stimulant of the respiratory function.

As a means to reduce the irritability of the vagus by local measures, cocainization of the nerve suggested itself and has been employed. Heller recommends regionary and perineural infiltration with novocain .5 per cent. in the posterior mediastinum at the level of the hilus of the lung and arch of the aorta and claims that thereby both the centripetal conduction from the respiratory system and the centrifugal impulses can be completely blocked, so that stimuli, which otherwise would induce cardiac and respiratory paralysis, remain inactive. The temporary paralysis of both vagi he claims to be harmless.

Above the bifurcation of the trachea careless handling of the vagi is still more dangerous than lower down in its likelihood to cause cardiac collapse, as we may there be dealing with nerves leading directly to the heart. In operating according to my method, in which the divided oesophagus is drawn through the neck, Lotheissen recommends starting at the neck under local anæsthesia, as does also Küttner, claiming that, by doing so, a regional block of the vagi is brought about; he enhances this blocking by an infiltration of the mediastinum from the neck wound. After the thorax is opened, the mediastinum is to be still further injected roundabout the vagi about the level of the bifurcation of the trachea, using 4 per cent. novocain. Then the separation of the nerve from the oesophagus is to be proceeded with and to be continued downward as far as the upper end of the tumor where, if the tumor is extirpable, the nerve is cut. However, Rehn's case of death from irritation of the cocainized vagus, cited above, seems to give evidence that the method of suppressing reflex irritability by the use of a local anæsthetic does not absolve us from caution in handling the vagus. To me, the best plan still appears to be, as I mentioned in an early publication, not to handle the nerve at all in liberating the oesophagus from it, but to keep close to the oesophagus until a place is reached where the nerve or a branch must be divided, and then to do it by a clean sharp cut.

*Shock.*—Deaths very soon after the operation have not been rare, and they have occurred after all the methods of procedure. Most of these are ascribable to that condition of suddenly lowered vitality which we term shock; some may have been vagus deaths.

*Cardiac Insufficiency.*—Much more frequently the patient apparently recovers from the operation, and his appearance on the following day is quite encouraging, but at the end of the second day or on the third day

the pulse becomes markedly weak, and the weakness progresses in spite of stimulation. Among my fatal cases cardiac insufficiency has played the leading rôle, other causes of death, such as infection and pneumothorax, having been the exception. The autopsy reports mention such findings as "heart enlarged, soft and flabby"; "ventricular walls thinner than normal and all cavities dilated"; "cardiac hypertrophy and dilatation"; "chronic valvular endocarditis"; "myocardial degeneration"; "congestion and œdema of the lungs"; doubtless also due to cardiac insufficiency.

The operation is often of such magnitude that the patient's vitality, and particularly his heart, is unable to hold out. When a patient is run down by the disease, is toxæmic, and his heart has suffered in consequence, his chances to pull through are small. To my idea, one of the most important problems is that of strengthening the heart sufficiently to undergo the task, and thus far that problem has not been solved. Cardiants of course are indicated previous to operation as well as subsequently, but in my experience they are of little avail in patients whose heart weakness is due to the toxic influence of a carcinoma. Lotheissen recommends the intravenous administration of ten cubic centimetres of a 50 per cent. solution of dextrose on the evening before the operation or for several days preceding. That impresses me as being a more rational procedure than the attempt to digitalize.

*Recurrence.*—Recurrence after operative recovery has either been metastatic or local. In some of the latter cases the excision is known to have been insufficient in extent, which brings home again the old lesson that the removal of an ample zone of apparently healthy tissue beyond the limits of the carcinoma is essential.

*Operative Cures.*—Of patients operated abdominally alone there were five cures, operated by Bircher, Kümmell, Küttner, Völcker, Brun. Besides these, Bircher had a case that lived fourteen days and died of pneumonia; Völcker one that lived twenty-four days; Ach one that lived seventeen days. In the last named case, after abdominal resection of the tumor, the œsophagus was removed by invagination upward.

Of combined abdominothoracic cases, Zaaijer and Hedblom each had an operative success in a two-stage operation. Both of these died a few months after operation.

Of thoracic cases, Lilienthal had an operative success in an extrapleural resection and Eggers in two transpleural resections. Lilienthal's and one of Eggers' cases died from recurrence, the other case is comparatively recent. The longest follow-up case of excision of a carcinoma of the thoracic œsophagus was a case of mine that died thirteen years after operation, without recurrence, just before her eightieth birthday.

*Animal Operations Compared With Those in Man.*—Why do operations on animals show so much better results than those on human beings? The



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diversity is due to a number of factors. (1) The dog's œsophagus is denser and firmer. (2) The resected portion has usually been very small, considerably smaller than would suffice even in a very early case of carcinoma. (3) The resected part in the animal was not diseased but normal. (4) The animal tissues being normal there was less likelihood of subsequent infection and a better chance for prompt union. (5) The tissues being normal a minimum amount of time was consumed in liberating the parts to be resected, whereas in the human being the separation of the extensively attached carcinoma prolongs the operation. (6) Finally, the animal experimenter never selects a dog that is suffering from a wasting disease or whose age is advanced but chooses a healthy subject.

*How Can the Results be Improved?*—As the operations on animals were not performed with greater skill and superior surgical judgment than those on man, it is certain that the general condition of the patient is a very important factor. I have already mentioned that most of my fatal cases succumbed to cardiac insufficiency, demonstrated at autopsy if one was obtained, often apparent previous to operation, sometimes suspected but not established to a certainty. If a method could be worked out by which the heart could be supported to stand the strain, it would help us very much. Of course this problem is met most effectively by operating before the disease has had a chance to lower the patient's vitality to a material degree, in other words, by getting the case early. But the difficulty lies in the fact that, as long as the mortality is so high, the early case will not be referred for operation, and as long as we operate only in late cases, our results will not show much improvement. Then, what shall we do about it? I should advise refusing to operate upon patients whose vitality has declined to any material degree in consequence of their illness, or if their resistance is unsatisfactory for other reasons. It is with a good deal of reluctance that I make this recommendation, for in cancer surgery it is my principle to extend to the utmost the indication for operating. Here, however, we are still facing the task of establishing a footing for this operation, so that it may obtain recognition by the medical public and eventually by the lay public.

If the decision is in favor of operating, there should be no delay, as otherwise the cancer will extend locally, give rise to metastases, and develop toxæmia or increase its severity. The metastases from which Zaaijer's successful case died, are likely to have formed during the long time that elapsed before the tumor was removed,—three weeks between gastrostomy and the first stage of the two-stage operation and again three or four weeks before the final operation, the resection. In one of my own cases, an extrapleural resection of the œsophagus through an approach similar to the one I employ for the transpleural operation, the autopsy revealed metastases that had not been found when gastrostomy was performed. In that case two months had elapsed between gastrostomy and resection, due to the patient's own procrastination.

## DISCUSSION

tion. I would therefore advise to operate as soon after the gastrostomy as the patient's condition will permit.

The main operation should at first be considered to be an exploratory one. When the tumor is well exposed and it then appears doubtful whether a clean surgical excision with a wide margin of healthy tissue is feasible, no attempt should be made to go any further. Cases in which the tumor cannot be readily separated from the surrounding tissue are better not operated, because the prolonged manipulation, the greater insult to highly irritable tissues, and the longer time needed for operating would augment the danger of shock. In an early case, where the tumor has no abnormal attachments, the time needed for dissecting out the œsophagus would not be excessive, approaching somewhat the ideal conditions found in the animal experiment. The œsophagus would also be of firmer consistency, its mucosa would show less congestion from irritation by the foul discharge, and, being more nearly normal, there would be less likelihood of an infection from that source; hemostasis would be easier in normal tissue than in infiltrated surroundings; the vagi would come off with less manipulation, and in every way the likelihood of shock and the strain on the heart would be diminished.

The picture of the present status of carcinoma of the œsophagus which I have presented is not a cheerful one, but nevertheless I am not despondent as to the future of this branch of surgery. The statistics of a 91 per cent. mortality which I have given, do not really present a true picture of the condition, unless certain modifying conditions are taken into consideration. Thus, the two patients who passed out from inanition should not have died. There is no excuse for their death, and the blame should not be laid at the threshold of the operation. Had they recovered, the mortality would have dropped to about 85 per cent., and had we not been overenthusiastic in extending the indication for operating into fields that should have been avoided, the recoveries would have been somewhere between 15 and 20 per cent. If we could claim that figure or one somewhat better, we would be able to make a very strong plea for having the patients referred for surgical treatment in the early course of their affection, when their health and strength have not yet been undermined, and then the results would show quite a marked improvement.

DISCUSSION: DR. WILLY MEYER, of New York City, remarked that Doctor Torek had fully covered all the possibilities that have taken the majority of these patients away. The principal point to be emphasized is that as in so many other cases of carcinoma patients with cancer of the œsophagus reach the operating surgeon too late. Neither patient nor doctor can always be blamed for this occurrence. In many instances, patients do not come to the medical adviser except when their trouble is far advanced. Sometimes the doctor who first sees these patients with advancing difficulty in swallowing does not lay sufficient importance on the symptoms complained of. This con-

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dition can only be improved upon by proper education of the public, and also by proper education of the medical profession. The educating of the public can be done by those medical organizations only that are able to reach the public in print in the daily press. The public must be taught that difficulty in swallowing may be just as serious as is acute abdominal pain in a case of acute appendicitis, that it may mean death if nothing is done. The public must be advised by the daily press that patients who have difficulty in swallowing which is not caused suddenly, after having swallowed a foreign body, should apply at a hospital without delay for careful investigation of the cause of the trouble, where the correct diagnosis can be made. The medical practitioner should not prescribe a tablet, or a pill, or a powder in such cases, but refer the patients to a hospital where a corps of trained men can, by proper teamwork, diagnose the case and thus likely catch the disease in its early stage.

For the radical operation of cancer of the oesophagus it was most unfortunate that it was born at about the same time when ray treatment was coming to the front. It was about twenty years ago when a number of aggressive surgeons who took interest in this subject were suffering from lack of material. The statement made in open meeting by that late, excellent colleague, Dr. Henry H. Janeway, who at that time was connected with the General Memorial Hospital in New York, was unforgettable. He then had 35 cases with malignant stricture of the oesophagus under his care that were treated by means of radium. When asked at a meeting of the New York Society for Thoracic Surgery what results he had seen, he said he had seen benefit in one case only and that had to remain doubtful because of microscopic examination of a piece of the tumor had not been made.

Since that time a number of cases of oesophageal stricture, due to the presence of a malignant growth, have been reported in the literature of the world as "cured by means of radium." Because surgeons were unable to report with certainty a series of happy results in this difficult chapter, and also on account of the naturally high operative mortality, it can be understood that the family physician as well as the patient were in favor of ray treatment. In order to get real light on this important subject, it seems to be a matter of necessity that those who are at present most influential in the medical profession should create an international commission, or call it an international committee, of three or five or six trusted men, consisting of an internist, surgeon, bronchoscopist, radiologist, pathologist and radium specialist for investigation of these reported cases of cure by means of radium, ascertaining that the patients really suffered from cancer of the oesophagus, and if so, whether they have been followed up. Such combined international work would be most important. It certainly cannot be denied that radium has cured malignancy of the skin and the mucosa with the deeper structures which in its pathological aspect was similar to that occurring in the oesophagus. But the real proof is missing so far.

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It is unnecessary to speak of the various operative methods that come into consideration. The point to emphasize is that Doctor Torek's transpleural radical operation has blazed the trail. There are now three patients on record operated upon by this method, Doctor Torek's one and Doctor Eggers' two, who have recovered from this operation in the Lenox Hill Hospital of New York. Surely, if this operation were practised by many more surgeons who take interest in this class of cases, more operative recoveries would soon be reported. By giving the proper anæsthesia into the hands of an expert, pneumonia can be avoided, in the majority of cases, and by adding a brief, air-tight drainage of the pleural cavity the danger of infectious pleurisy can frequently be overcome.

It should not be forgotten that at the present time *without the operation*, unless radium should be proved to be really curative sometimes, 100 per cent. of the patients suffering from œsophageal carcinoma die.

## CONGENITAL HYPERTROPHIC PYLORIC STENOSIS AND ITS OPERATIVE TREATMENT

By ALFRED BROWN, M.D.

OF OMAHA, NEBRASKA

A PARTIAL review of the voluminous literature on congenital hypertrophic pyloric stenosis establishes the fact that of late the majority of writers on the subject, whatever their specialties and personal leanings may be, believe that the condition, disease, or deformity, call it what you will, should be classified among those amenable to surgical therapeutics. It is a mechanical condition and consequently best combated by mechanical attack. Though this is true it is well for the surgeon to bear in mind constantly that he is dealing with a perverted physiology of the gastrointestinal tract which requires a more intimate knowledge of the needs of the infant body that it is the good fortune of the average surgeon to possess, and restrict his part in the treatment of the patient to two main lines of endeavor, leaving the remainder of the treatment in the hands of a competent pediatrician with whom he should coöperate.

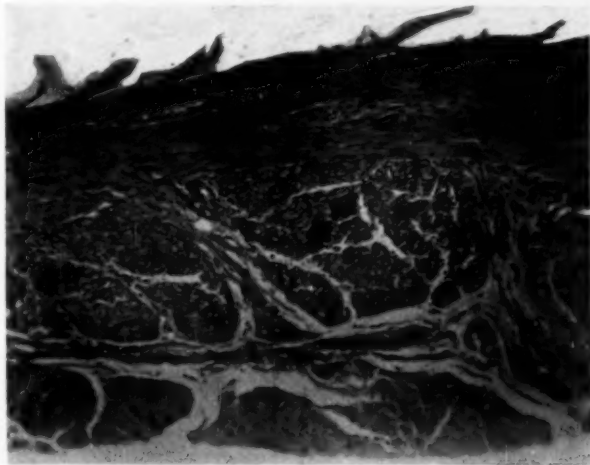


FIG. 1.—Section from pyloric stenosis in infant of four days. Note the normality of the muscle.

As the result of the more or less complete block of the passage of food from stomach to duodenum, caused by the tumor at the pylorus, there is present a certain degree of dehydration and acidosis. The patient presents the problem of partial, at least, high intestinal obstruction and the decision as to whether this should be attacked at once by surgical operation, or an attempt made to better the condition of the infant by means directed to overcoming the dehydration, constitutes the first of the duties of the surgeon. The second has to do with the operative procedure itself and the subsequent care of the wound. Aside from post-operative surgical complications which may occur, the remainder of the treatment rests with the pediatrician and is not in the province of the surgeon.

In congenital hypertrophic pyloric stenosis the strongest argument in favor of surgical intervention even in mild cases is the permanence of the tumor when treated by other methods. That it is permanent is demonstrated in



three ways: (1) Wollstein has shown that in cases which have died under medical treatment there is no change in the tumor and that gastro-enterostomy,

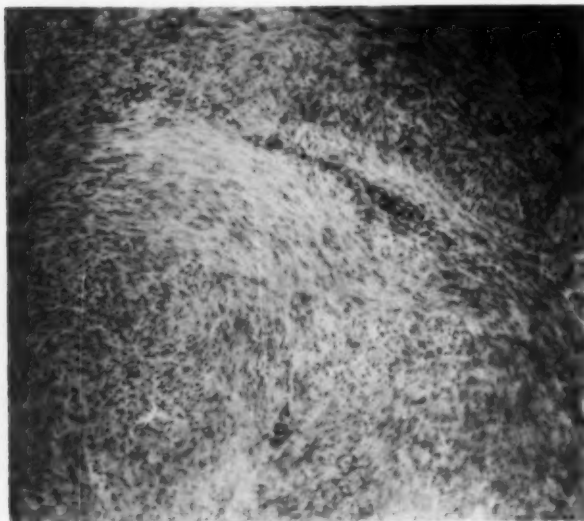


FIG. 2.—Section from pyloric stenosis in child of six and one-half months. Note the great amount of fibrous tissue present in the tumor.

though it relieves the symptoms and results in a clinical cure, has no effect on the tumor at the pylorus which remains unchanged. (2) Oliver reports a case in an adult of fifty-one years of age in whom a typical tumor was found and the patient recovered after a Rammstedt operation. Strachauer reports a similar case in a young man of twenty-one years of age with recovery after a similar operation. Cautley and Dent, Maylard, Landerer, and Russel have

also found tumors of the pylorus in adults which they believed to be congenital. (3) Histologically the tumor may undergo more or less fibrous change and thus tend to increase the amount of constriction as shown in Case IX of my series—a child of six and a half months of age. (See Fig. 2.)

With symptoms of vomiting of stomach contents without bile, at first regurgitation with later development of projectile vomiting; the appearance of a peristaltic wave passing from left to right across the upper abdomen; beginning loss of weight; scanty urine; stools without curds; accompanied in some cases by a mass palpable below the liver usually well to the right of the median line; operation is indicated without further waiting. Fluoroscopy and X-ray



FIG. 3.—Method of holding infant. Arms are bandaged while buttocks are raised.

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pictures are advised by some writers but in my series were used only once and in that case (Case XII), a male of forty-two days, the examination had been made before the child came under the care of Doctors McClanahan and Henske, by whom it was referred to me.

The earlier the operation is performed, the less shock results and the more rapid the convalescence. Feeding methods of treatment are not particularly successful and several cases have come to operation after futile attempts had been made, the only result being that the infant was in worse condition than



FIG. 4.—Method of holding infant. Bandaging of lower extremities completed.

if operation had been performed when the diagnosis was first made.

If the case is seen early and the child is in good condition it is operated upon at once. If the loss of weight is marked and dehydration is present, the

infant receives gastric lavage, proctoclysis of salt solution and glucose, and an intraperitoneal injection of salt solution. At the end of twelve or eighteen hours operation is performed as the maximum benefit is obtained by that time.

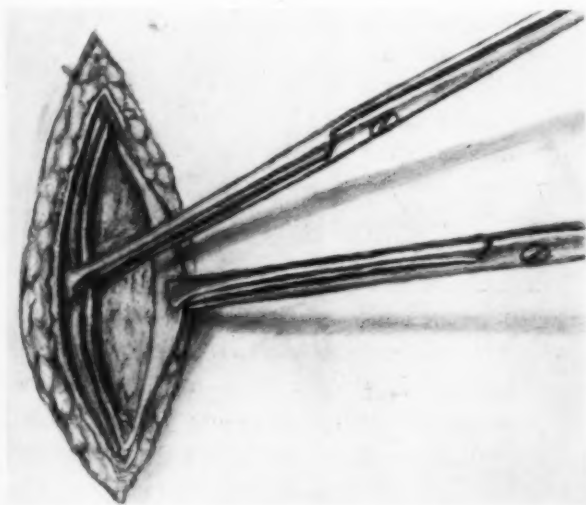


FIG. 5.—Abdominal incision made. Peritoneum and muscle grasped with Allis clamps.

Like so many other forms of successful medical and surgical treatment the discovery of the present-day accepted form of operation for pyloric stenosis was made by chance. The major

operations of dilatation of the pylorus by Loreta's method, pyloroplasty and gastro-enterostomy were accompanied by so high a mortality that operative treatment did not appear justified. In 1906 Nicoll performed an operation consisting of a V-shaped submucous incision at right angles to the long axis of the pylorus and converting this into a Y-incision by suture, thus



FIG. 6.—Line of incision mapped out. Note that it stops short of the pyloro-duodenal junction.

The incision thus divides the sphincter for some millimetres in depth (more than five certainly) and the lips of the wound part voluntarily. A series of linen sutures are placed as in the procedure of Heinicke-Mikulicz, transforming the longitudinal wound into a transverse wound, an autoplasty which manifestly enlarges the pylorus." In 1910 Weber described a similar procedure, and this description was seen by Rammstedt who attempted the operation but the stitches tore out and the split pylorus was returned to the abdomen after tacking a piece of omentum over the incision. The child recovered and in 1912 Rammstedt operated on a baby eighty-six days old, only splitting the pylorus. He describes his operation as follows: "An incision five centimetres long opens the abdomen in the mid-line at the level of the pylorus.



FIG. 8.—Muscle split and mucosa bulges throughout entire length of tumor.

increasing the diameter of the pylorus. Some success was attained by this method. In 1908 Doufour and Fredet published the description of a plastic operation on the pylorus which also did not open the lumen of the gut. They describe it as follows: "Incision of about two centimetres in the axis of the pylorus, on the middle of the anterior surface. This longitudinal incision goes through the peritoneum and muscularis but excludes the mucosa. The bistoury cuts a tissue which is white, mottled, bloodless, very hard, squeaking under the instrument, having the same appearance as certain uterine myomas.



FIG. 7.—Tumor incised. Muscle being split with handle of scalpel.

The stomach is enormously dilated. The pylorus is thicker than a thumb, cylindrical in shape, glistening reddish-white, hard as cartilage. Division of the thickened muscles on the anterior surface of the pylorus; only one circular suture at the point of change from pylorus to duodenum was necessary. The incision gaped widely and was left uncovered. Pylorus replaced, abdominal wall closed. Plaster bandage. Duration of the operation fifteen minutes. Ether narcosis."

The fundamental principle of the opera-

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TABULATED SYNOPSIS  
Twenty Cases of Pyloric Stenosis operated upon with no mortality.

| Case No. | Name  | Sex | Age at operation—days | Birth weight | Weight at operation | Per cent under weight | Onset age—days | Duration vomiting | Vomiting projectile | Wave | Tumor palpable | Pre-operative preparation time | Date of operation | Operation time | Day of discharge | Weight at dismissal | Remarks   |
|----------|-------|-----|-----------------------|--------------|---------------------|-----------------------|----------------|-------------------|---------------------|------|----------------|--------------------------------|-------------------|----------------|------------------|---------------------|---|
| 1        | H. H. | M   | 38                    | 12-0         | 9-13                | +                     | 28             | 10 days           | +                   | +    | 0              | 3 days                         | 7-3-23            | 8 min.         | 15               | 10-0                |   |
| 2        | M. J. | F   | 52                    | 5-0          | 6-0                 | 36                    | 35             | 17 days           | +                   | +    | 0              | 0                              | 11-14-23          | 8½ min.        | 6                | 6-2½                |   |
| 3        | W. A. | M   | 28                    | 10-0         | 7-15                | 0                     | 21             | 7 days            | +                   | +    | +              | 0                              | 1-16-24           | 8 min.         | 5                | 8-2                 |   |
| 4        | G. R. | M   | 40                    | 6-12         | 5-8                 | 50                    | 10             | 30 days           | +                   | +    | 0              | 29 days                        | 10-6-24           | 4½ min.        | 57               | 8-3½                |   |
| 5        | G. A. | M   | 90                    | 10-0         | 10-0                | 15                    | 42             | 48 days           | +                   | +    | +              | 0                              | 12-2-24           | 10 min.        | 6                | ?                   | Lost three pounds in 4 weeks  |
| 6        | D. H. | M   | 28                    | 9-12         | 8-7                 | +                     | 25             | 3 days            | +                   | +    | ?              | 2 days                         | 1-10-25           | 7 min.         | 4                | 8-7½                | Lost four ounces in 36 hours  |
| 7        | W. F. | M   | 49                    | 9-8          | 7-10                | 34                    | 14             | 35 days           | +                   | +    | +              | 0                              | 6-10-25           | 5 min.         | 11               | 8-2½                | At four years: 3'9"; weight 40 lbs. 1 oz. Well March 21, 1920. Weight 9½ at two weeks   |
| 8        | N. S. | M   | 84                    |              | 9-13                | 12                    | 17             | 67 days           | +                   | +    | 0              | 0                              | 11-21-25          | 7 min.         | 7                | 10-3                | Has right inguinal hernia   |
| 9        | C. W. | F   | 6½ mos.               | 7-6          | 17-6¾               | +                     | Birth          | Life              | +                   | +    | 0              | ?                              | 12-15-25          | 15 min.        | 6                | ?                   |   |
| 10       | T. H. | M   | 49                    | 8-3          | 9-10                | -                     | 42             | 7 days            | +                   | +    | 0              | 0                              | 4-11-26           | 7 min.         | 7                | 10-4                | Loss of eight ounces in week  |
| 11       | J. M. | F   | 28                    | 9-0          | 7-0                 | 7                     | 14             | 14 days           | +                   | +    | 0              | 0                              | 9-18-26           | 6 min.         | 4                | 7-14                |   |
| 12       | R. W. | M   | 42                    | 9-8          | 8-4½                | 11                    | 28             | 14 days           | +                   | +    | ?              | 0                              | 11-12-26          | 6 min.         | 13               | 8-15½               | X-ray shows retention   |
| 13       | R. T. | M   | 42                    |              | 8-1                 | 13                    | 35             | 7 days            | +                   | +    | ?              | 0                              | 12-1-26           | 10 min.        | 6                | 8-2½                |   |
| 14       | C. R. | M   | 41                    | 9-0          | 7-10                | 17                    | 29             | 7 days            | +                   | +    | +              | Int. inj. 2 days               | 4-16-28           | 8 min.         | 12               | 8-1½                | One child had P. S. and died following operation  |
| 15       | A. K. | M   | 53                    | 6-4          | 8-4                 | 20                    | Birth          | Life              | +                   | +    | 0              | 0                              | 5-26-28           | 7 min.         | 16               | 8-12                |   |
| 16       | P. B. | F   | 41                    | 8-2          | 9-0                 | 4                     | Birth          | Life              | +                   | +    | 0              | 0                              | 10-6-28           | 10 min.        | 4                | 9-5                 |   |
| 17       | E. H. | M   | 72                    | 10-0         | 7-8½                | 37                    | 21             | 5½ days           | +                   | +    | +              | 12 hours                       | 11-23-28          | 8 min.         | 12               | 9-10                | With intraperitoneal and proctoclysis gained three ounces in twelve hours pre-operative |
| 18       | R. R. | M   | 98                    | 9-8          | 8-14                | 28                    | 30             | 68 days           | +                   | +    | +              | 4 days                         | 12-23-28          | 8 min.         | 13               | 10-1                |   |
| 19       | R. J. | M   | 28                    | 11-0         | 8-15                | +                     | 14             | 14 days           | +                   | +    | 0              | 0                              | 1-25-29           | 5½ min.        | 12               | 9-1½                |   |
| 20       | J. G. | F   | 4                     | 7-8          | 7-0                 | 0                     | 0              | 4 days            | +                   | +    | 0              | 0                              | 3-19-29           | 9 min.         | 3                | 7-0                 |   |

tion for pyloric stenosis—splitting the hypertrophied muscle down to the mucosa and closing the abdomen—was thus laid down by Rammstedt and

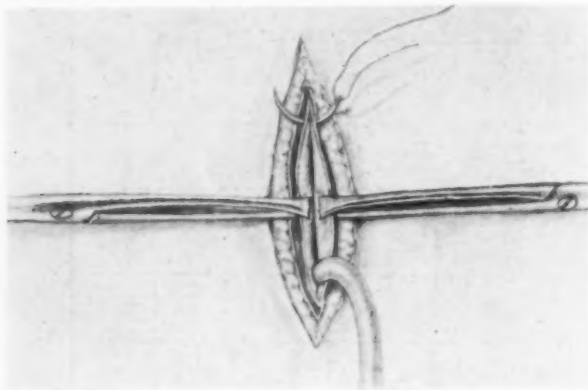


FIG. 9.—Catheter inserted. Peritoneum held in apposition with Allis clamps.

remains the fundamental principle of the operation today. Modifications of the technic so far as the pylorus is concerned tend only to make the operation more complicated, less easily performed, more time consuming and hence more hazardous.

In a series of twenty cases with no fatalities\* several points of technic have been developed which, though they are

not in any way modifications of the fundamentals of the operation, do appear to make it less dangerous and avoid certain difficulties which may arise. This operation is one of the very few in surgery in which I believe speed is of major importance. One is dealing with an infant, usually dehydrated and not in good condition and the less operative shock and the shorter the anaesthesia the better. I have not performed the operation under local anaesthesia but have employed ether in all cases. The infant is anaesthetized after everything is ready and the surgeon and assistant scrubbed up so that the incision is made immediately anaesthesia is induced and time so conserved. The infant is, as a rule, awake before it leaves the operating room.

*Operative Technic.*—All instruments and sutures are prepared and ready upon the instrument table and are reduced in number to those actually needed; namely: two small scalpels; two Allis clamps; one ring sponge forceps without serrations on the ring; two hemostats; one tissue forceps; one pair of scissors; two sutures of number zero chromic catgut threaded on full curved needles, one round and one cutting, and mounted in needle holders; and one rubber catheter, size 16 or 17 F., with a glass funnel inserted in its end.

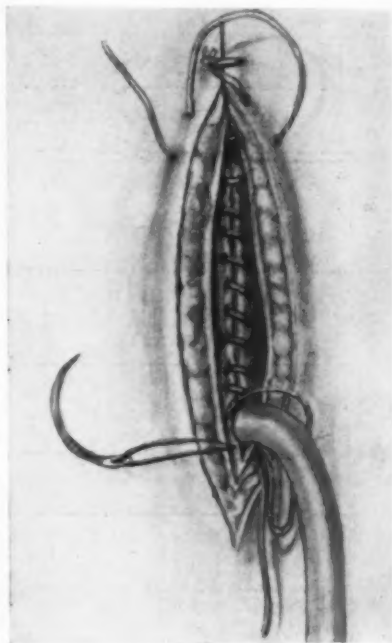


FIG. 10.—First row of sutures inserted. Second row started.

\* Since the above was written four cases have been operated upon successfully, making the series twenty-four cases with no fatalities to date.



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As anaesthesia is induced after the field is prepared and draped, the method of holding the infant is important. For it I am indebted to Miss Agnes G. Hain, R. N., at that time anaesthetist to the Bishop Clarkson Memorial Hospital, Omaha. A narrow, padded board is used which has previously been warmed. On this the child is laid and while its buttocks are raised up, the arms from axillae to wrists are bound to the board by a circular gauze bandage. (Fig. 3.) The buttocks are then let down and the bandage continued from pelvis to ankles. (Fig. 4.) In this way the infant can neither free nor harm itself and usually lies comparatively quiet during the induction of anaesthesia.

A right rectus incision from one to two inches long is made just above the level of the umbilicus. In the majority of cases, because of the dilatation of the stomach, the pylorus is pushed to the right and can be reached more easily through an incision in

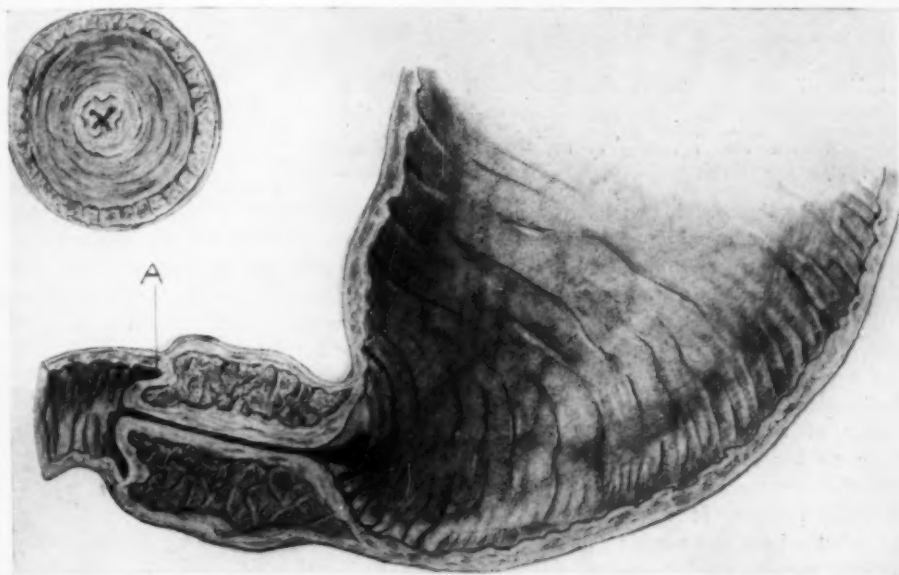


FIG. 11.—Longitudinal and cross section of congenital hypertrophic pylorus (after Richter). Note projection of the apex of the tumor into the duodenum. Incision at A will open the lumen of the gut.

this position than through one in the median line. As soon as the peritoneum is opened its edge, including a generous bite of the rectus muscle, is grasped on either side by an Allis clamp which is introduced from the side opposite the cut edge so that when it is turned over the peritoneum is everted (Fig. 5), and by pulling the clamps directly away from the abdomen and at the same time pressing their gripping ends together the two portions of peritoneum are brought into apposition (Fig. 9) and can be sutured without interference by the sticky cobweb-like omentum. No retractors are used and as a rule there is no bleeding.

The left index finger is introduced into the wound and the pyloric tumor sought for. As soon as it is felt a sponge forceps is passed along the finger, grasps the tumor and delivers it from the abdomen. It is then held between the index finger and thumb of the left hand which also serve to prevent the exit of abdominal contents. It has been my aim to allow the tumor, itself with only as much of stomach and duodenum as is necessary to permit delivery of the tumor from the abdomen, to be the only structures outside the abdominal incision, and in the great majority of cases this has been accomplished.

The tumor is then inspected for its most avascular area. Dyas has shown by injection of the vessels of the pyloric region in full-term babies that there is a rich plexus

of vessels upon the anterior surface of the pylorus with a comparative scarcity of vessels on the posterior surface. He therefore advises that the incision be made on the upper and posterior aspect of the pylorus. This, he states, can be accomplished by rotating the pylorus through an arc of ninety degrees and he has found that division of the pyloric attachments is not necessary to accomplish the splitting of the tumor in this area. I have made the incision through the whitest area above the terminal branches of the lower vessels on the anterior surface. (Fig. 6.) The incision is carried longitudinally along the pyloric tumor for its full length beginning just on the stomach side

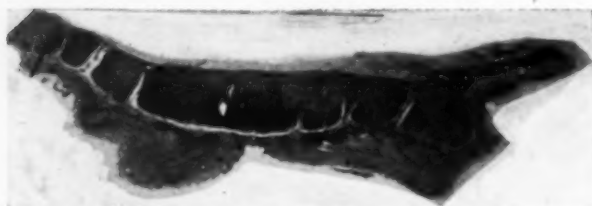


FIG. 12.—Low power photomicrograph showing full length of the tumor in congenital hypertrophic pyloric stenosis. Male baby six weeks old. (Courtesy of Dr. William Berry, Omaha, Nebr.)

of the junction of the tumor with the duodenum to avoid any danger of encroaching on the duodenum itself. The incision passes through peritoneum and superficial muscle layer only.

The next step in the operation, splitting the tumor, is, I believe, the most important one. Here the two greatest dangers of the oper-

ation, hæmorrhage and opening the mucosa, may arise. All observers who have described the tumor of congenital pyloric stenosis agree in the description of its duodenal end. It is described as projecting into the duodenum like a cervix into the vagina. (Fig. 11.) There is a reëntrant angle around the periphery of the duodenal end of the tumor which is lined by the junction of the pyloric and duodenal mucosa. This represents the point where, in the normal organ, practically all of the circular muscle of the pylorus stops and the greater portion of the longitudinal fibres of the dilator of the pylorus dip down to become interlaced with the circular muscles as shown by Horton. It is also the point where the vessels are not constricted by the tumor. Reference to Figures 11 and 12 shows that the apparent duodenal end of the tumor as felt by the fingers is situated beyond the point where the tumor joins the muscular and peritoneal layers of the duodenum. Consequently, if the incision is made over this apparent end of the tumor as felt by the fingers the lumen of the gut may easily be opened at the angle, or one of the large vessels be divided at this point, and disagreeable, if not serious, hæmorrhage result. However, in order to get the best result, it is necessary to divide the muscle fibres at the apex of the tumor as they represent the most marked point of constriction. This can be done safely by beginning the incision a short distance proximal to the duodeno-pyloric junction and dissecting bluntly with the handle of a scalpel working under the peritoneum toward the duodenal end of the tumor. When these fibres are divided the remainder of the tumor is split, still using the scalpel handle, until the mucosa bulges into the wound throughout its entire length. (Fig. 8.)

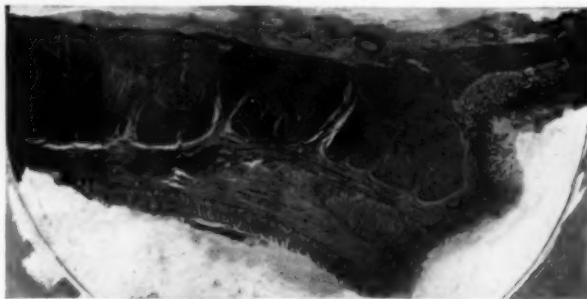


FIG. 13.—Photomicrograph of distal end of the tumor of pyloric stenosis, showing the projection of the muscle into the lumen of the duodenum and the relation of the large vessels to duodenal end of the tumor. Male baby six weeks old. (Courtesy of Dr. William Berry, Omaha, Nebr.)

The pylorus is now dropped back and the peritoneum and muscle sutured around a catheter inserted in the lower angle of the wound, the peritoneum being held together

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as described previously (Fig. 9) and the lowermost end of the suture inserted so that when pulled taut and tied the opening through which the catheter passes will be closed. (Fig. 10.) Normal salt solution is now poured into the peritoneal cavity through the funnel until it flows out around the catheter. This procedure was advocated by McClanahan and is designed to combat the dehydration. The catheter is then withdrawn and the suture tied. The final suture is then introduced, including skin and fascia of the rectus, and the wound dressed with vaseline and gauze held tightly in place with broad adhesive straps. If nothing untoward happens the wound is not dressed until the seventh day, when it is cleaned and powdered and the chromic-gut sutures allowed to come out of themselves later.

The time consumed in the operation detailed above has been as short as four and one-half minutes in a very desperate case and as long as fifteen minutes in a child six and one-half months old in whom an inspection of other organs was made. The average time in the twenty cases was approximately seven and three-quarter minutes. Hemostasis was not necessary in any case and in none was the mucosa opened.

The major points in the twenty cases operated by the writer are noted upon an appended chart which is self-explanatory.

Within the past month follow-up reports have been received from eleven cases. In all, the child is reported as above the average height and weight for its present age with no symptoms referable to the gastro-intestinal tract. Two other cases living in Omaha are known to be well and in good condition. From the other seven no word has been received.

### BIBLIOGRAPHY

- Armstrong, G.: *An Account of the Diseases Most Incident to Children from Their Birth to the Age of Puberty with a Successful Method of Treating Them*. London, 1777, p. 49. (Quoted by Foote, J.: *Am. J. Dis. Child.*, vol. xv, No. 5, p. 351, May, 1918.)
- Beardsley, H.: *Tr. New Haven Co. Med. Soc.*, 1788. (Quoted by Osler, Wm.: *Boston Med. and Surg. Jour.*, March 12, 1903.)
- Cautley, E., and Dent, C. T.: *Tr. Royal Med. and Surg. Soc.*, vol. lxxxii, p. 41, 1899.
- Cautley, E., and Dent, C. T.: *Lancet*, London, vol. clxiii, p. 1679, December, 1902.
- Davis, H. H.: *J. A. M. A.*, p. 686, August 30, 1924.
- Doufour and Fredet: *Rev. de Chir.*, vol. xxxvii, p. 208, 1908.
- Downes, W. A.: *J. A. M. A.*, p. 228, July 24, 1920.
- Dyas, Frederick G.: *Trans. Western Surg. Assoc.*, p. 185, 1926.
- Fowler, W. Frank: *ANNALS OF SURGERY*, December, 1925.
- Goldbloom, A., and Spence, R.: *Am. Jour. Dis. Child.*, vol. xix, p. 263, 1920.
- Haggard, W. D.: *J. A. M. A.*, vol. lxxi, p. 810, 1918.
- Henske, J. A.: *Nebr. State Med. Jour.*, vol. vii, No. 7, p. 227, July, 1922; *Nebr. State Med. Jour.*, vol. x, No. 9, p. 353, September, 1925.
- Holt, L. E.: *J. A. M. A.*, vol. lxviii, p. 1517, 1917.
- Horton, B. T.: *Am. Jour. of Anatomy*, vol. xli, p. 197, 1928.
- Ibrahim, J.: *Ergebn. d. inn. Med. u. Kinderh.*, vol. i, p. 208, 1908; *Ergebn. d. inn. Med. u. Kinderh.*, vol. xxiv, p. 233, 1923.
- McClanahan, H. M.: *Trans. Am. Pediat. Soc.*, vol. xxii, 1920.
- Moore, H. L.: *South Med. Jour.*, vol. xvii, p. 187, March, 1924.
- Nicoll, J. H.: *The Practitioner*, vol. lxxxv, p. 650, 1910.
- Oliver, J. C.: *ANNALS OF SURGERY*, October, 1922.

ALFRED BROWN

- Palmer, D. W.: Ohio St. M. J., vol. xii, p. 730, 1916; ANNALS OF SURGERY, vol. lxvi, p. 428, 1917; Trans. Assoc. of Resident and Ex-Resident Phys. of Mayo Clinic, vol. i, pp. 74-83, 1919; Arch. Pediatrics, September, 1922.
- Rammstedt, C.: Med. Klin., vol. viii, p. 1702, 1912; Centralblatt f. Chir., vol. xxxix, p. 1761, 1912; Centralblatt f. Chir., vol. xl, p. 3, 1913.
- Ransahoff, J. L., and Wolley, P. G.: J. A. M. A., vol. lxviii, p. 1543, 1917.
- Richter, H. M.: Abt's Pediatrics, vol. iii, W. B. Saunders, p. 452, et. seq., 1924.
- Sauer, Louis W.: Arch. Pediatrics, March, 1924.
- Strachauer, A. C.: Minnesota Medicine, March 1923; Trans. Western Surg. Assoc., p. 189, 1926.
- Strauss, A. A.: J. A. M. A., vol. lxxi, No. 10, p. 807, 1918.
- Weber: Berlin Klin. Wochenschrift, p. 17, 1910.
- Wollstein, M.: Am. Jour. Dis. Child., June, 1922.

## THERAPEUTIC ASPECTS OF GASTRO-INTESTINAL SUBCOMPETENCE

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AND

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THE divers functions of the units which constitute the digestive apparatus are so correlated and coördinated that unusual alterations in the activities of one unit are reflected in corresponding alterations in the functions of other units. This interdependence is manifest particularly promptly and regularly in gastro-intestinal motility, because propulsion of ingesta at rates appropriate to the functions of the various segments and timely expulsion from the distal segment are requisite to normal digestion.

Should peristaltic action exceed or fall below wholesome limits or the rhythm be upset, digestive disturbances occur. Conversely, unusual alterations in secretion or in absorption, in the character or in the transmission of nerve impulses, in the amount and in the potency of hormones and chalone and the presence of gross lesions, introduce abnormal variations in the tonicity and in the responsiveness of the muscularis. In consequence the size and shape of segments of stomach and intestine and the nature of their peristalsis are modified.

Repeated fluoroscopic examinations of more or less robust or frail but ostensibly healthy individuals enabled Mills (Mills, R. Walter: *Am. Jour.*



FIG. 1.—M. R. April 19, 1927. Soon after ingestion of barium. Hypotonic stomach and duodenum.



*Röntgenology*, vol. ix, p. 731, 1922) to recognize wide variations in the normal size and shape of gastro-intestinal segments and in their propulsive power. Similar examinations of comparably robust and frail individuals who had been healthy previous to onset of diseases of their digestive apparatus, which were present in early as well as in late phases, have revealed equally wide variations in abnormal size, shape and propulsive power.



FIG. 2.—M. R. April 9, 1927. Six hours after ingestion of barium. Slight duodenal retention. Main mass of barium in lower ileum. None in cæcum.

Information thus provided has helped to make earlier and more accurate diagnoses possible, is disclosing the origin and evolution of many ailments and is indicating means to obtain further information. The value of this knowledge in designating prophylactic and therapeutic measures is obviously great. In addition similar examinations repeated during and after treatment show not only why some measures are the more effective in treating certain patients but also how mistakes can often be avoided.

The factor of paramount significance is propulsive power. In general, if it is maintained within wholesome limits, which fluctuate materially in different individuals and at intervals in the same individual, digestive disturbances do not occur, and, if digestive disturbances are present, restitution of propulsive power is corrective. Hence the need to consider how propulsive power is maintained, how it is impaired, and by what means it may be rehabilitated.

The propulsive power of the gastro-intestinal tract provided by its neuromuscular equipment diminishes gradually but inconstantly and with periodic interruptions from cardia to anus. Progress of ingesta is commonly in inverse ratio to the normal calibre of the tube. Progress through the narrower portions results chiefly from local peristalsis; through the wider portions the pressure of ingesta propelled from proximal segments adds somewhat more to the propulsive power of local peristalsis. Transient obstructions occur normally at the outlets from stomach, ileum, and rectum. Propulsive power, because of its progressive diminution, has been likened to an inclined conduit wherein the diameter and declivity are variables and is called the gastro-intestinal gradient. Investigations of Alvarez have added

## GASTRO-INTESTINAL SUBCOMPETENCE

materially to knowledge of the production and control of gastro-intestinal propulsive power.

The gastro-intestinal gradient is disturbed by active and passive obstructions. Active obstructions to progress of ingesta are presented by gross intrinsic and extrinsic lesions and by prolonged hypertonic contractions which constrict the lumen of segments of the tube more or less completely. Passive obstruction is caused by hypotonicity and atonicity or subcompetence of the gastro-intestinal muscularis, consequent hypoperistalsis, subsequent dilatation, and stasis.

Whether the progress of ingesta be retarded by lesions that produce active or passive obstruction, the results are similar. Segments proximal to those obstructed are overdistended and forced to propel their contents against abnormally increased pressure. Demands for compensatory hyperperistalsis are made, first, upon the adjacent proximal segment, and, subsequently, upon those more remote, should the acute or chronic, active or passive, obstruction be unrelieved. There are significant dissimilarities between the forms of obstruction. More abrupt and more complete active obstructions tend to affect the entire digestive tract uniformly. Gradually increasing, less complete passive obstructions, although they also affect the entire tract, provoke more significant alterations in the less competent segments, that is, those having weakened neuromuscular apparatus.

Intrinsic causes of subcompetence are inherent or acquired frailties in the muscularis that predispose the cells to exhaustion and minute lesions that interfere with transmission of nerve impulses. Extrinsic causes are imbalance in central and visceral nervous systems, deficiencies in internal secretions (thyroid and adrenal) and in external secretions (liver and possibly pancreas), dehydration, anæmia, systemic fatigue and intoxication, unwholesome methods of living and obstruction in distal intestinal segments. The causes act singly or in combination and the segments more commonly affected are adjacent to structures which exert sphincteric and check-valve actions, namely, stomach and duodenum, terminal ileum and proximal colon, and rectum.



FIG. 3.—M. R. April 22, 1927. Seventy-two hours after ingestion of barium. Main mass of retained barium in cæcum, ascending colon and proximal portion of transverse colon.

Should the inherent weakness in the muscularis be the chief provocative factor, subcompetence develops sooner or later (more commonly between twenty and fifty) in consequence of fatigue incidental to normal activities according as the frailties are greater or lesser. Single segments are usually affected, the proximal colon, rectum, stomach, and duodenum in order of frequency. More often intrinsic and extrinsic causes are combined. Primary



FIG. 4.—M. R. April 26, 1927. Twenty-four hours after barium enema. Main retention as after ingestion (Fig. 3) in cæcum, ascending colon and proximal portion of transverse colon.

subcompetence of distal segments produces retrograde hyperperistalsis followed by hypoperistalsis and dilatation in proximal weaker segments. Thus occur single and divers combinations of multiple disturbances in the gradient. Subcompetence occurs in various segments without gross gastric or duodenal lesions, or they may coexist. Then the subcompetence of segments may be in provocative or consequential relationship to gross lesions, thus making diagnosis more difficult and complicating therapy.

The causes and consequences of subcompetence of gastro-intestinal segments and of the myocardium are strikingly similar.

Fatigue and exhaustion produced by disturbances in the neuromuscular

apparatus, excess, deficits, or alterations in concentration of media to be propelled and in distal or peripheral resistance, and chronic intoxication are the usual provocations. The effects are failures to propel contents and the subsequent passive stagnation or congestion. Diagnoses of the two states are simple and disclose the provocative factors, among them some that can and should be eliminated. Prognoses may be difficult for it is sometimes impossible to estimate accurately the recoverability of hypotonic smooth or cardiac muscle should existent injurious influences be eliminated and adequate rest be provided. Prophylaxis is quite the same, to wit: The avoidance of local, mental, and systemic fatigue and of intoxication. So, too, the chief thera-

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peutic measures are alike, reduction in distal or peripheral resistance, provision of adequate media of suitable concentration and restriction of mental and physical exertion, all to provide rest and opportunity for recuperation. However, one striking dissimilarity occurs in treatment. The heart produces the propulsive power for the circulation of blood, so cardiac lesions are paramount. Although the stomach and duodenum produce the most effective propulsive power that maintains the gastro-intestinal gradient, distal intestinal segments also contribute thereto. If any segment becomes irreparably injured, it may be excluded or excised and the gradient reestablished.

### CLINICAL ASPECTS

The causes and consequences of segmental subcompetence will be outlined. Operations are considered, as a rule, only when all appropriate non-operative measures have proved inefficacious after ample trial, and provided the mental and physical handicaps of patients do not suffice to make rehabilitation impossible. Occasionally patients who are self-supporting, sometimes the chief dependence of others, and cannot afford prolonged treatment for pronounced disturbances, which are

probably to some extent permanent, are given the more certain benefits to be derived from intervention without undue delay.

Non-operative measures, which include rest, diet, fresh air, sunshine, introduction of wholesome habits, etc., should be employed in preparation for operation as they lessen immediate dangers and expedite convalescence. They should be adopted as permanent modes of living following operations, to consolidate recovery and to obviate the development of other disturbances. These patients are seldom well-balanced mentally or physically so that however deftly a suitable operation is performed, it is only a part of treatment that should be continued throughout life.

The reason why operative treatment of patients so affected has been discountenanced is that subcompetence has been classified as a functional



FIG. 5.—M. R. December 3, 1928. Stomach and duodenum one and a half years after excision of terminal ileum, cæcum, ascending colon and proximal transverse colon. Hypotonicity less than before operation shown in Fig. 1.

disorder without anatomic lesions which is obviously absurd, and it has been expected that operation alone would restore perfect health to individuals who are not and never can be robust.

The operative revision of subcompetent segments unassociated with gross gastric and duodenal lesions will be considered first, and then the surgical treatment of patients in whom subcompetence and gross lesions coëxist.

*Subcompetence of Segments without Gross Gastroduodenal Lesions.*—

Single segments may be affected alone or all may be more or less subcompetent, and then the distal segments are first involved and have produced retrograde disturbances. Therefore, they will be discussed in reverse order.



FIG. 6.—M. R. December 3, 1928. No duodenal retention. Bulk of barium in proximal transverse colon six hours after ingestion of barium whereas before operation (Fig. 3) none had reached the cæcum.

times in sigmoid, often in ascending colon, cæcum; occasionally in terminal ileum, rarely in duodenum and stomach.

*Treatment:* Elimination of lesions provoking sphincter spasm, perineorrhaphy, and correction of habits.

*Ascending Colon and Cæcum.*—*Causes:* Inherent frailties in muscularis, nervous instability, stasis in rectum.

*Effects:* (a) Local—hypoperistalsis, dilatation, stagnation of contents even for seventy-two hours, absorption of noxious substances, superficial ulcers of mucosa, penetration of intact or ulcerated mucosa by bacteria, contamination of adjacent lymph glands (commonly by colon bacilli, tubercle bacilli, and sometimes streptococci), lymphadenitis and appendicitis. (b) Systemic—toxæmia, lymphogenous and hematogenous dissemination of bacteria, anorexia, malnutrition, intensification of nerves instability, glandular, osseous and pulmonary tuberculosis. (c) Retrograde—hyperperistalsis followed by hypoperistalsis, dilatation and stasis in terminal ileum, duodenum, and stomach, indigestion, nausea and periodic vomiting, especially after fatigue.

*Treatment:* Correction of rectal stasis, resection of terminal ileum, cæcum and first portion of transverse colon and implantation of the end of the ileum into the

*Rectum.*—*Causes:* Inherent and acquired frailties in the muscularis; irritations (hæmorrhoids, fissures, fistulas) that provoke spasm of the sphincter ani, rectocele, habitual failure to obtain evacuation.

*Effects:* (a) Local—rectal hypoperistalsis, dilatation and stagnation, absorption of noxious substances, ulceration of mucosa, penetration of rectal mucosa and transient superficial ulcers by bacteria, perirectal abscesses. (b) Systemic—toxæmia, lymphogenous and hematogenous dissemination of bacteria. (c) Retrograde—stasis, sometimes in sigmoid, often in ascending colon, cæcum; occasionally in terminal ileum, rarely in duodenum and stomach.



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side of the colon. The limits of bowel needing resection are usually more accurately defined by the inflammation in the regional lymph glands than by radiosopic examinations or the appearance of the bowel itself. Subsequent correction of habits, suitable diets, and avoidance of overfatigue will prevent a recurrence of similar disturbances.

CASE I.—B. B., female, secretary, twenty-eight years of age. Inherently atonic; of little endurance; obviously liable to tuberculosis because of malnutrition, chronic indigestion and constipation. Hyposthenic type. Stomach and sigmoid slightly atonic. Subcompetence of cæcum and ascending colon pronounced. Retention over seventy-two hours. All aggravated by fatigue.

March 29, 1916.—Resection of terminal ileum, cæcum, ascending and first half of transverse colon. Lymphadenitis advanced. Uninterrupted recovery.

October, 1916.—Stomach empties in seven hours. Constipation relieved. Endurance increased. Is within ten pounds of peak weight.

May 27, 1929.—Has worked constantly for thirteen years. Intervals of fatigue have produced digestive upsets and loss of weight, yet she has seldom been incapacitated even with colds. Stomach empties in six hours. No abnormality throughout intestinal tract. Endurance is as high as it ever has been though she is seventeen pounds under peak weight. A tendency to mild secondary anaemia has disappeared. Responses of lymph tissue and reticulo-endothelium, which formerly indicated scant resistance to tuberculosis, are now such as to suggest insusceptibility.

Comment.—This woman has been enabled to work constantly and satisfactorily and perhaps has been protected against tuberculosis which has affected relatives. She is not and cannot be robust.

Terminal Ileum.—Causes: Inherent and acquired frailties are uncommon. The usual provocation is stasis in the cæcum; occasionally it is appendicitis, rarely cholecystitis.

Effects: (a) Local—hypoperistalsis, stagnation of contents, absorption of noxious substances, penetration of mucosa and lymph follicles by bacteria, lymphadenitis. (b) Systemic—toxaemia, lymphogenous and hematogenous dissemination of bacteria, notably tubercle bacilli, and subsequent glandular, osseous and pulmonary tuberculosis develop in those who are susceptible (c) Retrograde—hyperperistalsis, subsequent hypoperistalsis and stagnation in duodenum and stomach; pain, nausea, vomiting, and lesser grades of indigestion.



FIG. 7.—M. R. April 6, 1929. Stomach, duodenum, and jejunum immediately after ingestion of barium. Skiagram taken five months after duodenojejunosomy (end-to-side anastomosis) performed to relieve duodenal incompetence. Compare with Figs. 1 and 5.

*Treatment:* Appendectomy, cholecystectomy or resection as above described. Appropriate after care.

CASE II.—G. F., school boy, eight years of age. For the past two years he has suffered periodically from attacks of pain in lower right abdomen, loss of appetite, nausea, and vomiting, but not constipation. Attacks have not been characteristic of appendicitis. Two barium X-ray examinations, months apart, revealed stasis in terminal ileum but no other abnormality.

January 12, 1929.—Laparotomy. No lesions discovered in biliary tract, stomach, duodenum, colon or even in terminal ileum. A long, large, non-adherent appendix in

which there was no gross evidence of present or past inflammation was removed. Rapid recovery.

May 29, 1929.—Boy has had no more attacks and has gained in weight and strength. Barium X-ray examination revealed normal propulsive power throughout gastro-intestinal tract.

*Comment.*—Irritation in an appendix, too slight to provoke acute inflammation, caused reflex obstruction and subcompetence in the terminal ileum which disappeared after appendix was removed.

*Duodenum.—Causes:* Inherent and acquired frailties in muscularis, stagnation in terminal ileum and proximal colon, loss of weight and of tone in abdominal muscles which permits the sagging of



FIG. 8.—M. R. April 6, 1929. Six hours after ingestion of barium. Main mass of barium in terminal ileum and proximal colon. Compare with Figs. 2 and 7.

small intestine and cæcum that increases compression of transverse portion of duodenum by pressure of superior mesenteric artery, appendicitis, and cholecystitis.

*Effects:* (a) Local—hyperperistalsis and regurgitation of contents into stomach, hypoperistalsis, atonicity, and stagnation, penetration of mucosa by bacteria, lymphangitis and lymphadenitis, œdema of mucosa, obstruction to discharge of bile and pancreatic secretions. (b) Systemic—malnutrition, restricted activity of pancreas and liver, toxæmia. (c) Retrograde—hyperperistalsis, later hypoperistalsis, dilatation and stagnation in stomach, anorexia, pain and malnutrition, restriction of activity of pancreas and liver, chronic pancreatitis and cholecystitis.

*Treatment:* Appendectomy, cholecystectomy, relief of stasis in distal intestinal segments, duodenojejunostomy (antecolic or retrocolic), accomplished either by lateral anastomosis or preferably by transecting the duodenum near the termination of its descending portion, inverting the distal end and implanting the proximal end into the side of the jejunum.

CASE III.—E. H., nurse, age thirty years of age. Two years previously appendix was removed because of recurrent attacks of subacute inflammation. Relieved of digestive distresses until two months ago when symptoms of cholecystitis developed. Material loss in weight and increasing severity of attacks led to reëxamination which revealed

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incompetence of the duodenum and a kink in the ampulla of the gall-bladder that explained attacks.

*April 9, 1928.*—No active cholecystitis present but evidence of previous pericholecystitis that had involved stomach and duodenum. Gall-bladder after removal showed not only kink affecting mucosa and submucosa but also stricture of cystic duct. Uneventful recovery following transfusion for thrombocytopenic purpura.

*April 2, 1929.*—Has regained health. Stomach and duodenum competent, emptying in three and a half hours.

*Comment.*—Combined influences of appendicitis in provoking cholecystitis and of cholecystitis in causing duodenal incompetence are notable. More remarkable was the probable correction of reduction in platelets (82,000) by the liver injury from cholecystitis. Recovery from duodenal incompetence and disappearance of tendency to abnormal bleeding confirm these hypotheses.

CASE IV.—M. R., secretary, thirty-three years of age. Never robust, but well and active until the age of twenty-six, when she had typhoid fever. Later she was thrown upon her own resources and in consequence overworked. Attacks of pain in lower right quadrant, nausea, vomiting, capricious appetite, malnutrition, constipation, loss of weight and endurance led to general atonicity and nervous imbalance. Incompetence of duodenum, cæcum, and ascending colon revealed by physical and X-ray examinations.

*June 6, 1927.*—Duodenum was dilated and atonic up to the superior mesenteric artery; stomach less dilated and atonic. Jejunum and ileum appeared normal. Cæcum and ascending colon boggy, dilated, and atonic. Many enlarged lymph glands, some as large as almonds, present in and behind the mesocolon from ileum to middle of transverse colon. Simple cyst of right ovary.

Terminal six inches of ileum, cæcum, ascending and proximal half of transverse colon removed. End-to-side anastomosis between distal ileum and proximal colon. Removal of right ovary. Recovery uneventful.

*December 16, 1928.*—Improved for six months after resection of cæcum and ascending colon. Then tonsillectomy for recurrent inflammation. Thereafter she began to have discomfort in right upper quadrant of abdomen, lost appetite, weight, and strength. Incompetence of stomach and duodenum revealed by physical and X-ray examinations.

At operation duodenum was more dilated and flabby than before and had elongated. Stomach not greatly different. Duodenum was transected proximal to superior mesenteric artery, distal end inverted, proximal end implanted into side of jejunum behind transverse mesocolon. Few adhesions remained from previous operation; healing of anastomosis excellent; no adenopathy present. Recovery delayed by infection of wound which healed firmly.

*April 6, 1929.*—Has gained in weight and so much in endurance that she has been promoted to a position of added responsibility which she had been unable to occupy. X-ray examination revealed no abnormality in size and peristalsis of stomach or in propulsive power of her gastro-intestinal tract.

*Comment.*—Had the duodenojejunostomy been performed at the first operation or soon thereafter, the rehabilitation of this woman's digestive apparatus and the restoration of her working capacity would have been more rapidly satisfactory. (See Figs. 1 to 8.)

*Stomach.—Causes:* Inherent frailties in the muscularis or those acquired by over-eating, rapid eating, and the excessive labor incidental to pylorospasm, antraspasm, duodenal stasis, and obstructions in more distant intestinal segments, grave anæmias, uræmia, appendicitis and cholecystitis.

*Effects:* (a) Local—hyperperistalsis followed by hypoperistalsis, dilatation, retention, and stagnation of ingesta, absorption of noxious substances, penetration of mucosa by bacteria, lymphangitis, and lymphadenitis, superficial ulcers, and alterations in secretions. (b) Systemic—malnutrition, reduction in blood and tissue chlorides (alkalosis), toxæmia, pain and indigestion. (c) Retrograde—vomiting.

*Treatment:* Appendectomy, cholecystectomy, alleviation of anæmia, uræmia, and correction of duodenal and more distal obstructions are more certain to be effective if suitable diets, rest after eating, and avoidance of fatigue are included in the after care. Operations upon the stomach to relieve subcompetence must be adapted to the state of the duodenum. Pyloroplasty to relieve pylorospasm if the duodenum is, or is going to become incompetent is quite certain not only to fail but also to make bad conditions worse.

CASE V.—I. O., school girl, sixteen years of age. Well until six months ago; since then, pain three hours after eating; refused to eat as directed. She has lost forty-three pounds. Physical and X-ray examinations indicated duodenal ulcer.

June 14, 1923.—Operation under combined gas and local anæsthesia. Stomach hyperirritable, antraspasm, dilated but supposedly not atonic. No duodenal ulcer could be found even on direct inspection of mucosa. Finney pyloroplasty performed after mobilizing duodenum.

June 23, 1923.—Immediate results of pyloroplasty were good but duodenal retention developed and a posterior gastro-enterostomy was performed.

July 2, 1923.—Stomach emptying well through gastro-enterostomy stoma. Wound healing excellent, but convalescence retarded.

January 20, 1925.—Following operation patient improved very gradually and intermittently until a few months ago. Then as the competence of her stomach returned, she rapidly regained weight and strength and is now quite well.

*Comment.*—Partial atonicity of the duodenum became almost complete following pyloroplasty and necessitated a gastro-enterostomy which was contraindicated as a primary operation as was a low duodenojejunostomy. A high end-to-side duodenojejunostomy might have provided the needed relief.

Gastro-enterostomy may afford temporary relief, but, if the pylorospasm disappears, other and perhaps more serious mental and physical distresses are likely to follow. It is probable that when both stomach and duodenum are inert and pylorospasm absent, if any procedure should be employed, it is a transection of the duodenum beyond Brunner's glands, closure of its distal end, and implantation of the proximal end into the side of the jejunum. (See M. R., Case IV.)

*Concurrence of Indurated Gastric and Duodenal Ulcers and Subcompetence in Stomach, in Duodenum or in Distal Intestinal Segments.*—Three cardinal factors enter into the production of indurated ulcers—primary injury, repeated or continued irritation, and restricted blood supply, and of these ischemia is the most significant. Hypæmia occurs to a degree during the contraction of normal peristalsis; it is accentuated in hyperperistalsis, and is most pronounced (ischemia) during spasm. Consequently only superficial, transient ulcers develop in segments after the muscularis has become atonic. Passive obstructions in distal segments tend to provoke hyperperistalsis in proximal segments. This explains why constipation so often precedes ulcers of the stomach and of the first portion of the duodenum which are liable to injury and also are subjected to the action of hydrochloric acid. Local irritation incidental to evolution of ulcers produces hyperperistalsis and spasm in the affected segment, and the resultant ischemia favors not only further induration of an existing ulcer, the development of other ulcers, but also leads to the fatigue of the muscularis and to ultimate dilatation and stagnation. Thus ulcers of the stomach, either along the lesser curvature or at the pylorus, and of the duodenum occur with or without subcompetence of distal segments, with and without gastric and duodenal subcompetence.

Operative treatment of gastric and duodenal ulcers is partially effective if it relieves symptoms, and fully effective if it removes the ulcer, reestablishes the gastro-intestinal gradient and thereby prevents the subsequent development of another ulcer or of other symptoms.

Conditions precedent to success of operations vary with the presence or absence of subcompetence in stomach, duodenum or in the cæcum which is the chief offender

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in the proportion of individuals in whom constipation has been a contributory influence in provoking the ulceration.

Excision of an ulcer along the lesser curvature succeeds if the stomach and duodenum are competent and there is no obstructive lesion in a distal intestinal segment. It is incompletely successful if only the stomach is subcompetent. Then a pyloroplasty is indicated. This would be contraindicated if there were passive obstruction in the duodenum. Under that condition a gastro-enterostomy would be necessary. Similarly, resection of a gastric ulcer near the pylorus combined with a pyloroplasty or a Billroth No. 1 is effective if the duodenum is competent; otherwise a Billroth No. 2 or a modified Polya is required. If incompetence is present, any form of operation is but part of treatment which should include every measure that can help to reestablish muscular tonicity.

Simple resection of duodenal ulcers and some form of plastic closure of the defect are satisfactory if the duodenum is competent. If it is incompetent, Billroth No. 2 or a transection of the duodenum with exsection of the ulcer, inversion of the distal end of the duodenum and implantation of the proximal end into the side of the jejunum is demanded.

CASE VI.—A. R., housewife, twenty-eight years of age. Symptoms of duodenal ulcer for the past two years; lost weight and strength, more particularly in the past few months. Is now unable to keep house and care for children. She cannot gain because food and work reawaken her ulcer symptoms.

*August 29, 1928.*—Laparotomy. No lesion in stomach. Tone good. Duodenum dilated and atonic; scar and stippling of serosa; ulcer healed. Duodenum transected at level of scar about three-fourths of an inch beyond pylorus; distal end inverted; scar and underlying mucosa excised; proximal end implanted into the jejunum behind the transverse colon.

*October 24, 1928.*—Some antraspasm but stomach is empty in four hours. Can take unrestricted diet without distress.

*March 5, 1929.*—Is not gaining in weight, because she has to work too hard. Is not losing; appetite is good, and there are no symptoms of any derangement of her gastro-intestinal tract.

*Comment.*—This patient's experience so far would justify the assumption that implantation of the proximal duodenum which contains Brunner's glands into the jejunum is more wholesome than a gastro-enterostomy and less upsetting to the gradient if, indeed, it is not restorative.

None of the above procedures is ample if there is passive obstruction in distal segments which remains uncorrected. Gastro-enterostomy alone is inadvisable if avoidable because the ulcer is not removed, the gradient is not reestablished, and both may cause trouble. If gastric subcompetence is present, it demands at least as much consideration as the ulcer for until it is corrected, recovery is impossible.

The chief objective of operations is to remove the ulcer and, when feasible, the cause thereof, to reestablish the gastro-intestinal gradient rather than to restore the normal channel, to minimize injuring vessels and nerves in order to preserve muscular integrity and to promote primary union, thus restricting the cicatrix. End-to-end anastomoses are least harmful as they interfere little with the circular muscle; end-to-side anastomoses are more harmful, and lateral anastomoses most harmful because they divide the circular muscularis of both segments and, therefore, should be no longer than is necessary to provide an adequate stoma. The farther separated the segments which are anastomosed, the greater the differences in their propulsive power, and the more certain the backing upward in the distal segment as exemplified in ileosigmoidostomy.

*Concurrence of Cancer of the Stomach and Subcompetence in Stomach, in Duodenum and in Distal Intestinal Segments.*—There are two types of cancer—the spontaneous and the induced. The spontaneous form develops without obvious precedent irritation. Maude Slye's investigations and the studies of Warthin (*Jour. Can. Res.*,



vol. ix, p. 279, 1929) and others have proved that the predominant causative influence is inherited. Potts first recognized induced cancer, the scrotal epithelioma of chimney sweeps, provoked by the irritation of coal soot. Many other irritants are provocative, among them indurated ulcers. Systemic defense against both forms of cancer is identical qualitatively but not quantitatively (Yates and Raine: *Lewis Surgery*, vol. iii, ch. 9). Deficits in defense offered by patients suffering from spontaneous cancer are inherent and less likely to become effective after the growth is removed. Deficits in defense against induced cancer are imposed by the action of irritants and are more likely to become effective after the growth is extirpated even though the removal is incomplete.

Extirpation of spontaneous cancer should be more radical, and if complete extirpation is impossible, radical operations that are particularly hazardous should seldom be attempted.

Extirpation of induced cancer need be less radical, and, even though complete removal is unattainable, extensive operations are justified as some of these patients will survive for many years (ten to twenty) apparently recovered, before they suffer recrudescence.

Gastric and duodenal subcompetence and passive obstruction in distal segments may or may not be present with either form of cancer.

The chief problem is how to reconstruct the digestive tract after extirpation. Here, as after extirpation of ulcer, the indications are to reestablish the gastro-intestinal gradient, rather than to restore normal anatomic relationships. Again it is necessary to correct any existing passive obstructions in distal segments.

#### SUMMARY

Disturbances in the gastro-intestinal gradient caused by passive obstruction resulting from subcompetence of the muscularis of one or several segments occur alone or with gross lesions of the stomach and duodenum, appendicitis, and cholecystitis.

Early in the development of passive obstruction, while the muscularis can be rehabilitated, non-operative measures will so often be successful that they should always be employed and in conjunction with appendectomy and cholecystectomy if indicated.

Later, when the muscularis of certain segments has become irreparably atonic or after non-operative measures have been proved inefficacious, operative restoration of the gradient is indicated in patients of sufficient mental and physical stamina to be benefited. If such operations are performed, non-operative measures should also be employed before and after operation as they hasten recovery and prevent the development of similar lesions in other segments.

Operative treatment of ulcer and cancer of the stomach and of ulcer of the duodenum is more certain to afford immediate and lasting relief if the gross lesions are removed and the gastro-intestinal gradient is restored.

#### CONCLUSIONS

All functions of the digestive tract are largely commensurate with motility.

Preservation and restoration of the gradient are the objects of gastro-intestinal therapy.

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Fatigue and exhaustion of the muscularis are the lesions that impose hypoperistalsis and dilatation which cause passive obstruction.

Passive obstruction is a frequent and serious disturbance of the gradient that should be remedied to rehabilitate digestion, prevent the development of other lesions in the gastro-intestinal tract and as a prophylactic measure against pulmonary, mesenteric, and retroperitoneal glandular and osseous tuberculosis.

The existence or probable development of subcompetence in stomach, duodenum or in distal intestinal segments is a factor which should help to determine the nature of operations employed to relieve indurated gastric and duodenal ulcers and cancer of the stomach.

## THE SURGERY OF PYLOROSPASM

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THE surgical physiology of the pyloric sphincter bears an important relationship to peptic ulcer. Aberrant functions of the sphincter, such as achalasia (failure to relax) and spasm, are considered to be due to disturbed innervation. The resultant changes in the chemism and motor function of the stomach are represented clinically by the syndrome of peptic ulcer. (This aspect of peptic ulcer was discussed at the 1928 meeting of the American Surgical Association by Martin and Burden.) It often happens, however, that symptoms typical of ulcer occur where neither Röntgen-ray examination

nor laparotomy demonstrate the presence of ulcer. From this fact it may be assumed that the disturbed physiology is the cause and not the effect of ulcer. A logical corrective measure for the interference of disturbed pyloric function would be division of the nerve supply as practiced by Schiassi<sup>12</sup> and by C. H. Mayo<sup>8</sup> or by direct attack on the sphincter through the operation advocated by Shoemaker and by Martin and Burden,<sup>7</sup> in which the anterior half of the sphincter muscle is removed.

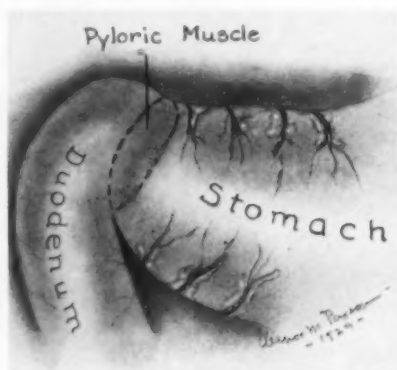


FIG. 1.—Removal of portion of pyloric muscle. First step: Lines of excision.

Although the operation on the pyloric muscle was originally devised for the relief of pylorospasm, in view of the afore-mentioned surgico-physiological relationship of the pyloric sphincter to peptic ulcer, it occurred to us to apply it to cases of duodenal, gastric, and gastrojejunal ulcer as well as to pylorospasm associated with hyperacidity or with disease of the gall-bladder and of the appendix. We herewith present the results of our experience with the operation which we have termed hemisphincterectomy pylori or pylorohemisphincterectomy.

*Theory of the Operation.*—The hydrochloric acid of gastric juice is probably the most important single factor in the development and maintenance of peptic ulcer. The clinical studies of Bolton<sup>3</sup> and Hurst,<sup>5</sup> and the experiments by Boldyreff<sup>2</sup> and Mann<sup>6</sup> are confirmatory. The nearest approach to clinical conditions was obtained by surgical duodenal drainage. By this method, Mann was able to produce typical peptic ulcers. In his experiments the chemism of the stomach was not significantly changed and the ulcers

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were not located in the duodenum but in the transplanted jejunum. These findings indicate that normal gastric juice will cause ulceration of the jejunum—a fact of no little significance in the etiology of gastrojejunal ulcer. By extending these experiments, Norton found that gastrojejunostomy performed after the appearance of the ulcer following surgical duodenal drainage, led to the prompt healing of the original ulcer and the formation of a new ulcer in the jejunum opposite the gastro-enteric stoma, a chain of events very closely simulating the clinical development of gastrojejunal ulcer.

In the development of duodenal ulcer, we may assume either that the duodenum has been rendered unnaturally sensitive to normal gastric acid through deprivation of its normal protective mechanism or that the concentration of hydrochloric acid leaving the stomach is beyond the endurance strength of the duodenum. From clinical and experimental studies the latter assumption seems to be the more tenable. Boldyreff's work, which has been confirmed by many others, showed that the gastric juice when secreted always contained about 0.5 per cent. hydrochloric acid which normally is reduced to 0.2 per cent., the optimal strength for digestion. Experimental studies favor the opinion that regulation of gastric acidity depends on regurgitation of duodenal contents into the stomach, although the inherent capacity of the stomach to regulate its own acidity must be considered.

Elman's<sup>4</sup> investigation of clinical cases of duodenal ulcer revealed a constant deficiency of duodenal regurgitation, which was probably caused by pyloric interference. Spasm of the pyloric sphincter and its failure to relax in coördination with gastric function, abnormalities not uncommon to sphincters elsewhere along the gastro-intestinal tract, may be assigned as a reasonable hindrance to duodenal regurgitation. Failure of duodenal regurgitation and the development of hyperchlorhydria permit the squirting into the duodenum of acid of injurious strength and the point of impingement of the stream becomes the site of an ulcer. The same theory applies to the development of gastric ulcer, in which the retention in the stomach of hyperacid gastric juice has been proven to cause single and multiple ulcerations.

After a gastrojejunostomy has been made for duodenal ulcer there is often a failure to note a change in gastric acidity, yet many of these patients remain well; a few will develop marginal ulcer. The latter lesion has been known to occur even when analysis finds a reduction in acidity. Such findings are significant. Estimation of gastric acidity by analysis of test meals, in our opinion, does not represent the true every-day working conditions in the

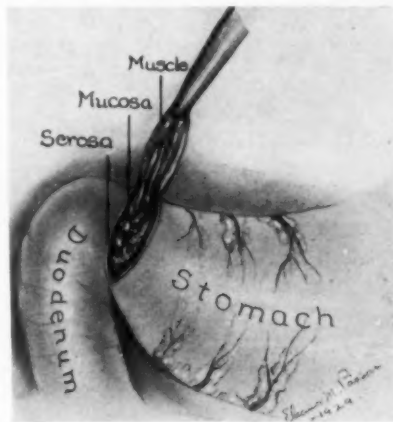


FIG. 2.—Removal of portion of pyloric muscle. Second step: Removal of muscle.

stomach. When gastro-enterostomy is successful, there is regulation of gastric acidity by reflux of duodenal contents through a free and patulous pylorus or through the new stoma, or through both openings. However, for reasons not at present explainable, the onward current in the proximal loop may sweep past the gastro-enteric stoma and there will be no regulation of gastric acidity. The latter condition is a potential marginal ulcer. The jejunum is more sensitive to hydrochloric acid than is the duodenum, so that it is possible for jejunal ulcer to develop from the effects of normal gastric juice.

Appendicitis and cholecystitis are frequently associated with peptic ulcer to a degree that has aroused suspicion of a causal relationship. The tracing of lymphatic paths between these foci of infection has fitted in nicely with the surgeon's creed that infection is the origin of most diseases. However, we cannot disregard the frequent mimicry of peptic ulcer by disease of the gall-bladder and the appendix in cases where the symptoms are explained by reflex pylorospasm. By putting these phenomena in sequence we have disease of the appendix or of the gall-bladder, reflex pylorospasm, disturbance of acid-alkali balance at the pylorus, and finally, peptic ulcer.

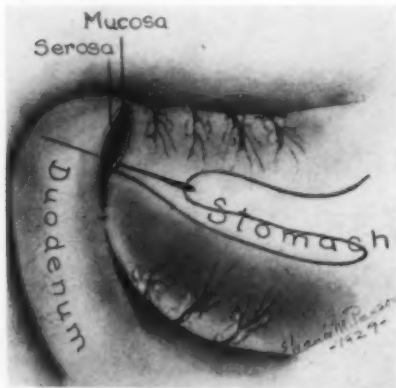


FIG. 3.—Removal of portion of pyloric muscle. Third step: Closure of serosa.

factory results. Resection of the anterior half of the pyloric sphincter through a double elliptical transverse incision naturally removes more of the muscle ring and renders less likely a resumption of the function of the sphincter, because its two ends are so widely separated that the small amount of interposed scar tissue cannot bring them together. The senior author has, many times, made a longitudinal section of the muscle for pylorospasm when operating for gall-stone disease.

*Technic of the Operation.*—After opening the abdomen by an upper right rectus incision, the gastroduodenal area is exposed and held under tension by drawing the stomach out and to the left. The pyloric sphincter may be readily located by the landmarks of the short, transverse veins; an elliptical area, including the anterior half of the sphincter, is formed by two curved transverse incisions, one on either side of the sphincter. These incisions are carried down to the submucosa of the stomach and duodenum. The lower end of the elliptical area, including the sphincter, is cut across and with the aid of the scalpel it is peeled off the underlying submucosa and again cut across at its upper extremity. The resulting oval effect, exposing the submucosa, is closed by a continuous suture which unites the gastric and duodenal serous



## THE SURGERY OF PYLOROSPASM

edges. Penetration of the submucosa should be carefully avoided, especially on the duodenal side and should it occur, the opening must be securely closed by suture. Wide extension of inflammatory œdema or of scar tissue from a nearby ulcer are contraindications to this operation because of the difficulty of placing holding sutures in such pathologic tissue. Ordinarily the ulcer is not disturbed, but in a few instances we have deliberately excised the ulcer in addition to removing the anterior half of the sphincter. In three cases of acute perforation of a duodenal ulcer we have closed the perforation and then resected the sphincter. When the operation has been properly performed there is no appreciable narrowing of the pyloric outlet, although this occurred in one of our early cases and required a secondary gastro-enterostomy to relieve obstruction. The defect remaining after removal of the oval piece of tissue containing half the sphincter should be closed to control oozing from the incised edges and to avoid the chance of leakage, because the duodenal submucosa is very thin.

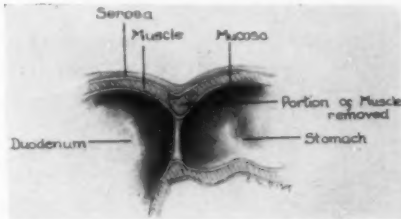


FIG. 4.—Section through stomach and duodenum showing portion of pyloric muscle removed.

### SUMMARY OF CASES

Thirty-one patients were operated on of whom twenty-seven were males and four females. The ages by decades were eight in the third, thirteen in the fourth, four in the fifth, five in the sixth, and one in the seventh. This series of cases is obviously too small to warrant conclusive statements. It is not offered for comparison with the results of other procedures used in peptic ulcer, but merely as a record of our experience.

All patients gave a more or less typical history of peptic ulcer; six having a history of hæmorrhage. The duration of symptoms ranged from one week (acute perforation) to twenty years. An X-ray examination of the stomach and duodenum was made in sixteen cases and reported positive for ulcer in eight.

*Operative Findings.*—Duodenal ulcer was found in twenty-three cases of which three were acute perforations. Gastric ulcer was found in three cases of which one was an acute perforation; nine had cholecystitis, seven of which had an associated duodenal ulcer and two pylorospasm. Pylorospasm was found in four cases, two with cholecystitis, one with appendicitis, and in one it was the only finding. One patient had a gastrojejunal ulcer.

*Operative Procedures.*—The anterior half of the pyloric sphincter was excised in all cases. Additional operative procedures included excision of duodenal ulcer in four cases, gastrojejunostomy in one case, cholecystectomy in nine cases, sleeve resection of the stomach in two cases. One patient died in the hospital from uræmia. Of the remaining thirty patients, eighteen reported to the follow-up service. Of these, fifteen, or 83.3 per cent., were completely relieved of symptoms, two reported marked improvement,

and one only moderate relief. X-ray studies made after operation in twelve cases showed no gastric retention, no hyperperistalsis and only slight deformity of the pyloric canal. In one case the stomach emptied more rapidly than normal. Analysis of fractional test meals were made in nineteen cases before operation and showed the usual varying values for free and total acidity. Fractional test meal studies were made by Doctor Engel in eight patients in the follow-up service and found to be within normal limits; in no instance was there an absence of free hydrochloric acid. In our experience, gastric analysis has been of little help either in the diagnosis or prognosis of peptic ulcer. In this connection, we believe Morton's work in gastroduodenal analysis seems promising. He found that in cases of peptic ulcer and of pyloric achalasia the duodenum always contained free hydrochloric acid, while in normal controls it was absent.

## CONCLUSIONS

Thirty-one cases are reported in which the anterior half of the pyloric sphincter was removed for the relief of duodenal ulcer, gastric ulcer, gastrojejunal ulcer, and pylorospasm.

The high percentage of beneficial results following this minor anatomical procedure seems to justify its more extended use.

The theory of the operation is based upon correction of malfunction of the pyloric sphincter.

## BIBLIOGRAPHY

- <sup>1</sup> Bastianelli, R.: Pylorus Spasm and Its Surgical Treatment. *ANNALS OF SURGERY*, 1925, vol. lxxxi, 45-51.
- <sup>2</sup> Boldyreff, W.: The Self-regulation of the Acidity of the Gastric Contents and the Real Acidity of the Gastric Juice. *Quart. Jour. of Exper. Physiol.*, 1914, viii, 1-12.
- <sup>3</sup> Bolton, Charles: Discussion on Diseases of the Stomach with Special Reference to Modern Methods of Investigation. *British Med. Journal*, 1923, ii, 269-274.
- <sup>4</sup> Elman, R.: The Rôle of the Pancreatic Juice in the Regulation of Gastric Acidity; Report of Forty-fifth Meeting of Soc. of Clin. Surg., 1925, 17-20.
- <sup>5</sup> Hurst, A. F.: The Sphincters of the Alimentary Canal and Their Clinical Significance. *British Medical Journal*, 1925, i, 145-151.
- <sup>6</sup> Mann, F. C.: Chemical and Mechanical Factors in Experimentally Produced Peptic Ulcer, *Surg. Clin. of N. A.*, 1925, v, 753-775.
- <sup>7</sup> Martin, E., and Burden, V. G.: Pyloric Achalasia and Peptic Ulcer. *ANNALS OF SURGERY*, 1928, 565-575.
- <sup>8</sup> Mayo, C. H.: Division of Vagi for Pylorospasm. *ANNALS OF SURGERY*, 1928, lxxxviii, 669.
- <sup>9</sup> Morton, C. B.: Observations on Peptic Ulcer, I. II. III. *ANNALS OF SURGERY*, 1927, lxxxv, 207-238.
- <sup>10</sup> Morton, C. B.: Observations on Peptic Ulcer, VI. *American Journal of the Medical Sciences*, 1929, clxxvii, 65-72.
- <sup>11</sup> Payr, Arch. f. klin. Chir., 1925, cxxxviii, 649-671.
- <sup>12</sup> Schiassi, B.: The Rôle of the Pyloro-duodenal Nerve Supply in the Surgery of Duodenal Ulcer. *ANNALS OF SURGERY*, 1925, lxxxi, 939.

## THE MANAGEMENT OF RECURRENT ULCER FOLLOWING PARTIAL GASTRECTOMY

By DONALD C. BALFOUR, M.D.

OF ROCHESTER, MINN.

A YEAR ago I reported before this association a group of fifty-three cases of recurrent ulcers following partial gastrectomy. These cases were divided into three groups: (1) twenty-eight cases in which the ulcer was found at operation; (2) twenty cases in which a clinical or röntgenologic diagnosis (or both) of recurrent ulcer was made, but chiefly because of mild symptoms the patients did not come to operation, and (3) five cases in which the subsequent course pointed definitely to recurrent ulceration or was suggestive of it. The cases in which the ulceration was found at operation were classified according to the type of primary resection and to the lesion for which the primary operation had been done. Since this report three patients with recurrent ulcers following partial gastrectomy have been operated on at the clinic, making a total of thirty-one cases found at operation at the clinic.

There are certain inherent difficulties in the treatment of these cases. They are chiefly based on the fact that a characteristic of peptic ulcer is recurrence, a tendency which is, in some respects, more marked than in any other disease. The control of this tendency to recur is accomplished with variable success by medical and surgical measures, and it is a tribute to surgical treatment that an adequate operation, in cases in which it has not been possible to prevent recurrence by medical treatment, usually is successful. There are some patients, however, in whom recurrence occurs in spite of radical surgical procedures. In these cases recurrence is due, in all probability, to an exaggeration of the normal tendency to recur rather than to the addition of new causative factors, although the latter is possible.

There are certain difficulties, also, in the evaluation of symptoms which develop or persist after partial gastrectomy. In the first place recurrence of dyspepsia does not necessarily mean the presence of ulcer; the symptoms may be due to other disease, either intra-abdominal or extra-abdominal. The symptoms also may be a result of mechanical imperfections in the anastomosis, or to disturbances in gastric function, which are quite independent of any recurrent lesion. Recurrence of symptoms also may be due to localized inflammatory processes without the actual formation of ulcer; in such cases symptoms may simulate closely those of ulcer, although the pain is rarely as severe as in ulcer. Difficulties in diagnosis also are encountered by the röntgenologist, since deformity from a previous operation will easily confuse interpretation; to make a positive diagnosis on röntgenographic data is hazardous as the irregularities visualized may be due either to deformity or to actual ulcer.

Difficulties continue to be found in determining the best method of treat-

ing patients in whom recurrence of symptoms suggestive of ulcer have developed after partial gastrectomy. If patients manifest mild symptoms, even with positive röntgenographic evidence of a crater, continuation of non-surgical measures may be advised until all other possible means of relief have been definitely exhausted. The dangers of delay must be appreciated, however, since a recurring ulcer after partial gastrectomy more frequently will be associated with serious complications than a primary ulcer, and the complications are much more difficult to deal with than those which accompany primary ulcer. Usually, however, the symptoms are so severe, and expectant treatment has been proved so inadequate that little choice remains as to further management, and operation must be performed.

The difficulties of medical and of surgical treatment in these cases are well known. It is frequently found that if recurrence has developed, particularly after more than one resection has been done, the patients do not display the willingness to coöperate, which is so desirable. Some patients obtain relief by the use of sedatives and some, by taking milk at half-hourly intervals. In many cases, long-continued distress, loss of sleep, and deferred hope have brought about complete disability. I have been told repeatedly by this type of patient that a cigarette relieves tension, so that some of these patients become cigarette addicts. In some cases the pain becomes so severe or so persistent, particularly at night, that the patients have resorted to opiates and become habitués.

Response to medical treatment in cases of recurrent ulcer is less likely than in cases of primary ulcer. I am not convinced that this is always because in recurrent ulcer, the symptoms are more severe or that the possibility of quieting the activity of the ulcer is less than in primary ulcer, but rather that the long-continued disability and particularly the repeated disappointments have brought about hypersensibility to pain. It is a temptation to try every nonsurgical means suggested for the control of recurrent ulcer. The use of vaccines has not, in my experience, been followed by any definitely good results. The application of Röntgen-rays to reduce gastric acidity has been tried experimentally, and to a slight extent clinically, but, so far as I know, permanent good results have not been obtained. It is important to eradicate all foci of infection before deciding that the lesion will not heal.

Weir has demonstrated recently certain facts in relation to acidity; his data are based, in most cases, on repeated fractional estimations of gastric content, and, in some cases, on aspiration of gastric content at the time of maximal pain. Of the twenty-nine cases of recurrent ulcer following partial gastrectomy, achlorhydria was present in 20 per cent. In 40 per cent., gastric acid was definitely reduced, and in 10 per cent. only was high acidity demonstrated. This appears to be sufficient evidence that elimination of gastric acidity does not necessarily protect the patient against further ulceration.

The surgical treatment of recurrent ulcer following partial gastrectomy cannot be conducted on the same basis as that employed in primary ulcer, chiefly because the patient already has demonstrated that in his case there

## RECURRENT ULCER FOLLOWING PARTIAL GASTRECTOMY

is a distinctly higher liability to recurrence. The purpose of operation for primary ulcer is not only to relieve the patient of the symptoms of the ulcer, but to protect him against recurrence. If both objects can be obtained by a conservative operation, so much the better. The fact that recurrence takes place in such a small percentage of cases after a properly performed conservative primary operation, based on adequate indications, means that if relief of symptoms can be accomplished by a conservative operation, there is little justification in doing a radical operation. This is particularly true in view of the fact that more radical primary procedures do not assure protection against recurrence.

Incomplete operation for ulcers that recur following partial gastrectomy probably will fall in its dual purpose, that is, relief of symptoms and protection against further ulceration. However, further resection is often technically very difficult, and the surgeon is confronted with a most serious problem both from the patient's standpoint and from his own.

There are two types of such recurrence in which a conservative operation may be warranted: First, are recurrences following the Billroth No. 1 type of resection or of its modifications. In these cases particularly, if obstruction or impending obstruction is present, gastro-enterostomy may bring about complete and permanent relief of symptoms. The advantages, therefore, of an indirect procedure in such cases should not be lost sight of, particularly if the patient is in poor condition or if the inflammatory process is extensive. Second, are recurrences in which a protected perforation has occurred following an extensive resection of the Billroth No. 2 type with wide involvement of surrounding structures in the inflammatory process. Preliminary jejunostomy in such cases will bring about marked regression of the inflammatory process and will permit carrying out a radical procedure with much greater safety as a secondary rather than as a primary procedure.

In all cases other than these, secondary resection is indicated. The technique of secondary resection does not require description before this Association. There are certain general principles, however, which are worthy of mention. It is most important, for example, that trauma, particularly to mucosa of the stomach and jejunum, be reduced to a minimum. I am convinced that some recurrences can be attributed to devitalization of mucosa near the line of anastomosis. A second principle is that a radical change should be made in the type of gastro-enteric anastomosis. A third principle involves the use of a jejunostomy tube for feeding in cases in which the lines of anastomosis have been difficult to establish. A fourth principle is that such patients must realize that every possible contributing factor to the tendency to recurrence should be eliminated. Tobacco and alcohol should be prohibited; foci of infection should be eradicated; a most meticulous dietary regimen should be maintained, and proper adjustment of bodily activity and relaxation should be made. The maxim of such patients should be: "Alternate rest and labor—long endure."

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## DISCUSSION

DISCUSSION: DR. GEORGE W. CRILE, of Cleveland, Ohio, said that any discussion of this subject always brought out the limitations which both medical and surgical attack, in the last analysis, reveal. He hesitated to introduce any new facts on a subject of this kind.

In hypothyroidism and myxœdema hydrochloric acid is low or absent, while in hyperthyroidism hydrochloric acid is high. Nervous excitation and adrenalæmia tend to increase the acidity of the stomach. Associated with hyperacidity is an increased motility.

Doctor Crile mentioned that Miss Amy Rowland, Dr. J. I. Farrell, and he had tested the following hypothesis: Hydrochloric acid is always present in the stomach, and the small intestine is alkaline throughout the entire biologic series, this alkalinity being assured by the pouring into the duodenum of the highly alkaline bile and pancreatic juice.

The acid stomach and the alkaline intestine, therefore, form a great biologic battery, consisting of the acid gastric juice and the great area of alkaline intestines separated by the innumerable cells in the intestinal and stomach walls which thus constitute a dielectric partition.

Such an hypothesis is readily tested by measuring the potential between the stomach and the intestine.

This measurement has been made, and there is found a large difference in potential between the interior of the stomach and the interior of the intestine, amounting to approximately 25 millivolts. Such an active, biologic battery would create a continuous electrolysis, especially at the pole of highest potential. Such a battery would tend to break down the gastric wall by electrolysis; in other words, it would produce and maintain a gastric or duodenal ulcer, and an increased motility.

Among the excitants of increased acidity in the stomach and of hyperthyroidism is adrenalin. Experimentally, adrenalin exerts a profound effect on the potential of the gastric side of the theoretical battery and has but slight effect on the intestinal side.

Now, in a resistant, post-operative, recurrent case of hyperthyroidism it was found that unilateral adrenalectomy and resection of the cervical sympathetics stabilized the patient beyond the effect of the thyroidectomy alone. Therefore, it is proposed in a case of intractable gastric or duodenal ulcer to perform a similar dekineticizing operation, relieving the patient partially of his accelerating mechanism, bringing down permanently the difference of potential of the great intestinal battery, hence lowering the electrolysis, and lowering the motility, the latter probably being one of the functions of the gastro-intestinal battery.

DR. ARTHUR D. BEVAN, of Chicago, Ill., remarked in regard to technic of operations for pyloric stenosis: "I rather think the Rammstedt operation has been developed so that one might speak of it as one of the most finished products in modern surgery. We are doing all of these operations under local anæsthesia. I think that is tremendously important.

"Most of these children go to sleep under local anæsthesia if they are

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given a nipple and a bottle, if the local anæsthesia is properly handled. In order to prevent the escape of the abdominal contents during the operation, there is an anatomical fact in connection with the operation which is very important. It is this: In the child the liver comes pretty well down below the costal arch. The infiltration should be made in the right rectus and the incision should be made so that two-thirds or three-fourths of the muscle is left on the outer side. Then as you open this incision with retractors you come down to the liver. The liver should be the one structure that fills this entire field, and the lower part of the peritoneum should not be divided.

"We found in quite a series of cases that this technic has prevented the escape of any of the abdominal contents and made the operation simpler. The liver then is lifted up, the stomach is pulled into view, and the operation is performed. In dividing the tumor we have found that it is simply necessary to divide the peritoneum and then to do the rest of the dissection with very small forceps, a mosquito forceps or a small artery forceps. In that way you can avoid injuring the duodenum.

"We do not attempt to divide anything but the peritoneum. Then we spread the tumor apart down to the submucous layer, and bring out the mucous tube without any further division.

"The third point that I should like to emphasize is the importance of preventing a possible evisceration some days after the operation, because wound repair is very often very slow in these little starved children. At the end of ten days you may not have any more wound repair than may occur in a normal child in three or four days, so that provision against evisceration must be maintained for about twenty days. This is best obtained by adding to the ordinary closure of the incision two or three small button sutures which can be left in fifteen or even twenty days if necessary."

DR. ALLEN O. WHIPPLE, of New York City, reported the results at the Babies' Hospital of New York in the treatment of pyloric stenosis in infants.

The total number of cases that were operated on at the Babies' Hospital was 648. Of these Doctor Downes' and Doctor Bolling's cases, together, number 584, Doctor Bolling having performed the larger number, 384.

The total mortality for the whole series is a little less than 5 per cent. Doctor Downes wishes to emphasize particularly that in Doctor Bolling's private cases, 76 in number, the mortality was 2.6 per cent.

In recent years at the Babies' Hospital the operative mortality in pyloric stenosis has rapidly decreased, owing to the fact that this condition is better understood generally, and the patients come to operation in better shape than formerly. It is also due to the fact that treatment before and after operation is better understood. The liberal use of transfusions and saline solution have aided materially in obtaining these improved results. The technic of the operation as done follows the original Fredet-Rammstedt method. Late results in cases done as long as fifteen years ago show that these patients are restored to normal health by this simple operation and develop in every way as well as other children.

## DISCUSSION

A further report shows that sixty-four cases have also been done by Doctor Donovan at the Babies' Hospital, with a mortality of less than 6 per cent.

DR. LEONARD FREEMAN, of Denver, Colorado, discussing Doctor Brown's paper on hypertrophic congenital pyloric stenosis, said that the causation is not clear in everything that he had read on the subject. It is usually attributed to spasm in the pyloric muscle, and that seems to be a very reasonable solution. Yet there are objections to this. Spasm occurs in a good many muscles in the intestinal tract. It occurs very frequently in the pyloric muscle and yet a tumor does not develop. Spasm occurs also in the cardiac opening of the stomach, and yet we see no tumors. Anal spasm is a very common thing, lasting for a long time, yet tumors of that muscle develop.

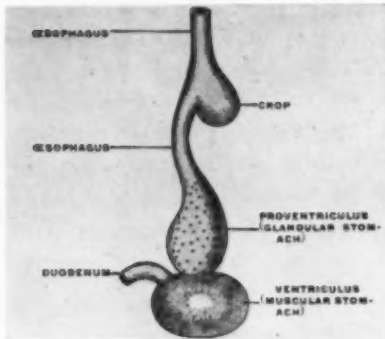


FIG. 1.—Anatomy of the human peritoneum, Huntington, 1903.

In the next place, these tumors in pyloric stenosis in infants appear very shortly after birth. They are found a few days after. They have even been found at birth, and they have also been found, a number of times, in the foetus before birth. It is very difficult to understand how pyloric tumor could develop in such a muscle without having some length of time to do so. Also it is not known that spasms occur in the pyloric muscles of unborn infants. To this may be added what Doctor Brown has said—that these muscles do not disappear after the symptoms disappear and the patient is supposed to be cured.

If these tumors are not due to muscular spasm what are they due to? It occurred to Doctor Freeman some years ago—

and he stated he has spoken of it elsewhere—that they were probably rever-  
sions to an ancestral type. These throwbacks to ancestral types are quite common in the gastro-intestinal tract as is known. They can all be referred back to some animal in a lower line of existence. If that is so, then what animal is of particular interest?

Take for instance the graminivorous birds. The gizzard in these graminivorous birds is situated in exactly the same spot as the pyloric tumor under discussion. Also, in some of the rather higher mammals, the same sort of thing is found. In the animal called the colored anteater, for instance, there is a stomach. The outlet of the stomach is occupied by a heavy muscular

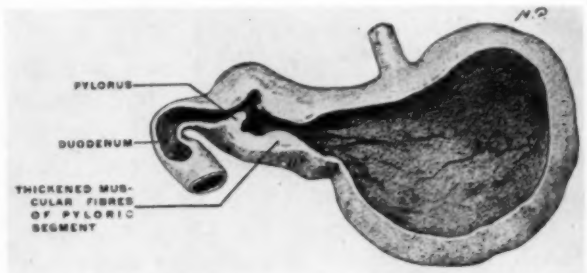


FIG. 2.—Anatomy of the human peritoneum, Huntington, 1903.

## GASTRIC SURGERY

tumor in the same situation as the tumor in hypertrophic pyloric stenosis. This is a suggestion of causation.

DR. J. SHELTON HORSLEY, of Richmond, Va., spoke of recurrence of peptic ulcer after operation, or after medical treatment, which is always interesting. Doctor Finney has shown that it recurs frequently after medical treatment. Other analyses of series of medically treated ulcers have appeared in the *American Journal of Medical Sciences* some time ago. These show an even more impressive percentage of recurrences.

He said that it seemed to him unfortunate to divide the treatment of ulcers of the stomach into medical and surgical treatment. There must be medical treatment in all of the cases, and there must be surgical treatment in some of them. The type of treatment that is adopted may have something to do with it. Dragstedt, some years ago, showed that the best way to make an experimental peptic ulcer in a dog was to put a series of sutures in one portion of the pyloric mucosa. This mucosa secretes alkaline material and is peculiarly liable to development of peptic ulcer. He has been doing a pyloroplasty for a good many years, and he found a great number of recurrences at first, as many as 25 per cent. He tried to trace cases accurately. The recurrence was along suture lines. He put in sutures and tied the knots in the pyloric mucosa. Usually the recurrence has been at the end of the suture line where the knots were. Since that experience, he has abandoned suturing the pyloric mucosa, and has dispensed with the inner row of sutures. He sutures the peritoneal and muscular coats of the stomach, catching the vessels on the submucosa, and when the duodenum is reached the whole wall of the duodenum is caught in the suture. At the upper portion of the wound the suture merely approximates the peritoneal and muscular coats of the stomach—again taking care not to clamp the gastric mucosa of the pylorus with forceps. This method controls the bleeding satisfactorily.

He is using the pyloroplasty in a more restricted field than at first. He thinks, however, that it has a definite field. In cases in which there is persistence of a small, sharply marked ulcer of the first part of the duodenum, without adhesions or surrounding infiltration, this operation seems indicated.

Since using the operation in a rather restricted field, he has had no real marked recurrence except in two cases, and those cases were easily cured by medical treatment. If the recurrence were a jejunal ulcer after gastroenterostomy, instead of a duodenal ulcer after pyloroplasty, the situation would be much graver.

In regard to the operation that Doctor Deaver described, he is wondering what the later results will be. If you take out a part of a sphincter it probably repairs by connective tissue. That connective tissue tends to contract. It contracts more readily in some areas than in others. The profession knows there is a proneness for stricture to occur at the pylorus and such a stenosis is often very difficult to cure. Then after this operation the posterior part of the sphincter with its nerve supply is left intact. It might be better to divide the sphincter ends and interpose the gastric wall as in the pyloroplasty

## DISCUSSION

he had mentioned, or to destroy at least a portion of the nerve supply of the pylorus by the procedure of Walter Hughson, who resects some of the gastric branches of the vagus nerve, which is easily done. Certainly there would be no danger of stenosis after either of these operations.

DR. WILLIAM D. HAGGARD, of Nashville, Tenn., supported what Doctor Bevan had said about the usefulness of local anæsthesia in the infants with pyloric stenosis.

He did his first case in 1916, and since then has had no occasion to use any other type of anæsthesia. He has had no difficulty with evisceration. As a matter of fact, the little people do not make very much fuss. He thinks it is not any worse for them than when they have their ordinary change of raiment.

He wants to call attention, too, to an unusual complication that can occur. The profession thought when it got past hæmorrhage and peritonitis that all of its dangers were gone. But Doctor Haggard recently had a fatal issue from alkalosis in an infant that had been carried along by feeding for a prolonged period of six weeks. Although the operation was very satisfactorily concluded, within twelve hours the infant had major convulsions, followed by a number of smaller ones, and though every agency to overcome the alkalosis was employed he perished. He even went so far as to use the parathyroid injection with the hope of establishing the calcium metabolism and thereby make the base for his acid production. It is the only time he has heard of post-operative alkalosis after the Rammstedt operation.

DR. WILLY MEYER, of New York City, said that at the coming meeting of the American Gastro-enterological Association, which is to take place at Atlantic City within a few days, a discussion on the cause and management of recurring gastric ulcer after partial gastrectomy is on the program. One colleague is going to report that in ten patients the left vagus nerve was divided from the abdomen, with the intention of reducing the recurrence of pain and intense acidity. Those patients remained cured. Of course, it would be better if fifty or sixty such cases could be reported instead of ten. If corroborated by others, more favorable reports will appear quickly. The operation is not difficult technically.

He mentioned this, because it has been his impression in operations on the stomach, also after gastro-enterostomy, that the gastric and the entire sympathetic nervous system play an important rôle during the immediate and later after-treatment.

He thought it deserved to be mentioned in this discussion that in ten cases of this resection of the left vagus nerve, done premeditatedly, there had been observed no recurrence of pain and hyperacidity.

DR. JOHN C. OLIVER, of Cincinnati, Ohio, said that Doctor Brown's reference to a case of congenital pyloric stenosis reminded him of a case which he reported to this Society six or seven years ago, and gives him the opportunity of reporting on the man's condition at the present time.

This man was fifty-one years of age at the time. He made a diagnosis



## GASTRIC SURGERY

of pyloric stenosis of the congenital type with a great deal of fear and trembling. He also did a Rammstedt operation with a great deal of fear and trembling. He is glad to say that this man, at the present time, seven or eight years afterward, is perfectly well, and has gained forty pounds.

DR. CHARLES H. MAYO, of Rochester, Minn., said that he believed the primary cause of ulcers of the stomach was acids. Next he looked on them more and more as having to do with the sympathetic nervous system. Various changes in circulatory conditions would have to be present in order to have the several factors that would be necessary for an ulcer to develop.

We talk of the healing and recurrence of ulcer. He does not believe that any ulcer that has given two or three periods of trouble heals at all between the attacks, whether there is pain or not. In the old varicose ulcer of the leg there is perhaps a similar condition. In these cases, there is a big sore that looks painful but which does not cause pain. One man with a varicose ulcer said that usually he had no trouble at all. However, "When I am laid up," he said, "there is a purple spot around the thrombotic area. I cannot walk. I have to keep it hot and I have to keep still. There is a little red spot on one side."

The little thrombus is at the margin of the ulcer that is getting larger. As this spot appears, pain comes on and the symptoms of ulcer develop.

Years ago he cut the nerves around ulcers of the leg. For about three years he has been cutting nerves in cases of gastric ulcer. Leriche has been running a knife around the stomach at the pyloric end, about an inch and a half above the pylorus, and cutting the sympathetic nerve supply. After doing a good many for a year, he was operating one day and one of the röntgenologists, standing by him, asked him what he was doing. He said he was cutting the innervation, to see if he could relax the pylorus. The röntgenologist said, "You should go above the angle of the stomach. An ulcer at the angle of the stomach will produce more spasm than an ulcer in the pyloric end of the stomach or the duodenum."

He began to cut the big right vagus nerve, and the gastric artery, cutting through the lesser omentum halfway between the cardia and the angle of the stomach. But this does not interrupt all of the vagal supply, because, as in the Leriche operation, in which the outer coat is peeled from a section of the artery of the leg to eliminate the sympathetic supply of the artery in the lower part of the limb, many fibres of the sympathetic nerves are supplied to the artery at lower levels and relief is, therefore, for four or five months only. By cutting as he has described, all the tissue, including the artery, would be severed. Nevertheless, if the fingers are inserted under the short side of the stomach and pull is exerted on it by lifting it a little, creases will be found. Each one of them is caused by a thread-like nerve fibre that is as strong as silk. The vagus nerve has branched higher up and the branches have spread out. A number of fibres will be found. You can work the knife through them until they pop.

Doctor Hartzell studied the effect of section of the vagus nerves in dogs.

## DISCUSSION

In some animals, he sectioned the vagus nerves just above the diaphragm and found that there was a marked reduction in both free and total acidity. In other animals, he sectioned the vagal branches in the abdomen and found that although the free acid was somewhat reduced the secretory curve was shorter, and the stomach emptied more rapidly.

Doctor Mayo finds that by cutting the nerves in the human being he has caused reduction of acidity. It takes many years to know what you are doing and to determine whether it is going to be better than anything else. But it is interesting to see that the acids are lowered by the procedure he has outlined.

DR. JOHN L. YATES, of Milwaukee, Wis., remarked that there are a few facts that merit emphasis. Subcompetence of gastric or intestinal segments is the result of lesions in the neuromuscular apparatus. Purely functional disorders are a myth. Subcompetence causes passive obstruction which interferes with digestion and impairs morale, and even when not associated with ulcer demands correction. A majority can be corrected without operation, but when this is impossible, operations are indicated only in the patients of some physical and mental stamina.

When subcompetence and ulcer of the stomach or duodenum coexist, the subcompetence is possibly incidental but more often is either the cause or the result of the ulcer. If causative, subcompetence occurs in distal intestinal segments, provokes retrograde hyperperistalsis in stomach or duodenum and thus contributes to the development of ulcer. If consequential, subcompetence occurs in stomach or duodenum, the result of previous hyperperistalsis incidental to the development of the ulcer, and contributes to stasis or retention.

Disturbances in the gastro-intestinal gradient cause indigestion; restoration of the gradient relieves indigestion. If intestinal subcompetence contributes to the development of ulcer, it is futile to treat the ulcer and neglect the cause.

There are three objectives in treating patients suffering from ulcer: (a) Relief from symptoms; (b) removal of the lesion; and (c) restoration of the gradient. If gastric or duodenal subcompetence coexists with ulcer, the operation of election removes the ulcer and restores the gradient rather than normal anatomic relationships. We believe, therefore, that subcompetence of gastro-intestinal segments is therapeutically significant either as an independent lesion or in causal or consequential relationship to ulcer, and that inasmuch as maintenance or restoration of the gradient is the objective of gastro-intestinal therapy, subcompetence must be duly considered in all aspects.

DR. DONALD C. BALFOUR, of Rochester, Minn., said he believed that such operations as Doctor Deaver has described and those which are designed to simplify the management of peptic ulcer are very well worth while. The simpler the method by which the symptoms of ulcer can be permanently controlled, the better it is for the future of the patient.

The second point is one which he mentions with some hesitation, since

## GASTRIC SURGERY

everyone recognizes the place which Doctor Finney holds in the field of gastric surgery. Any figures which Doctor Finney presents carry the weight of authority. It would be most important, therefore, to know the cause of death of these patients, and also to know whether the primary diagnosis was finally established. It seems astonishing that such a high death rate should have occurred in the first six months after indirect operations for duodenal ulcer.

Twelve years ago insurance actuaries showed that in 3000 patients who had been operated on for duodenal ulcer, the life expectancy was actually better than that of the general population group of the same age and sex. This is at such variance with the figures presented this afternoon that it seems probable that reconsideration of the cases Doctor Finney has included in his statistics would disclose an explanation for the discrepancy between the two reports.

## PROCESS OF UNION AFTER FRACTURE

By FREDERIC W. BANCROFT, M.D.

OF NEW YORK, N. Y.

FROM THE LABORATORIES OF THE DEPARTMENT OF SURGERY, COLLEGE OF PHYSICIANS AND SURGEONS, COLUMBIA UNIVERSITY

IN THE repair of fractures there are certain steps in the process that we know, and there are other phases about which we must theorize until our knowledge increases. It would seem advisable to present before this Association the things we know and the things we surmise.

We know the gross steps of repair—that is, hæmorrhage resulting from the injury—the later output of callus, at first gelatinous in consistency and

later becoming calcified, with resultant union. Microscopically we have observed the hæmorrhage, the ingrowth of wandering cells, the formation of granulation tissue, and, later, the ossification of this connective tissue.

We do not know, although we may surmise, the exact type of cell that enters into this reparative process. We do not know the particular activity of this cell. We know little

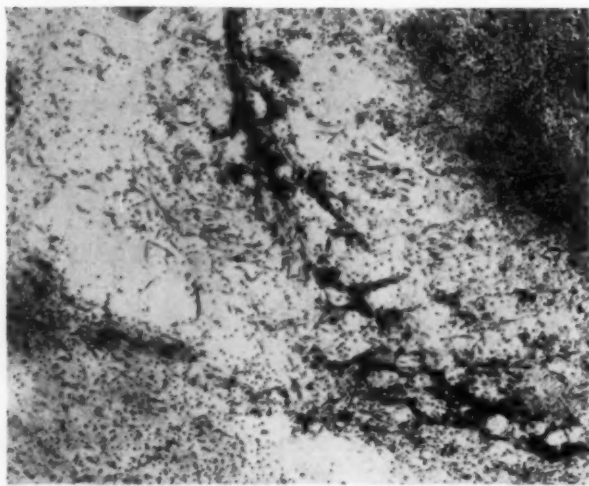


FIG. 1.—Curetings three days after fracture of patella. Note fibroblasts invading blood clot, beginning calcification of stroma.

of the physicochemical changes that turn calcium and phosphorus into bone.

Therefore, it would seem advisable to review briefly what we know about the healing in fractures, and then to attempt to build up from the various theories a working hypothesis which will be of service in the clinical treatment of patients with broken bones.

*What We Know About Repair in Fractures.*—Gross Description of Repair. Any force sufficient to break a bone, whether it be by direct or indirect violence, must by necessity injure the neighboring soft tissues—muscles, blood vessels, lymphatics and frequently nerves, skin and subcutaneous fat.

In our rabbit experiments the femur was broken with a single tap of a hammer. No immobilization of the leg was attempted. On inspection ten hours later the muscles were badly traumatized; hæmorrhage extended between muscle bundles and along fascial planes often to an astounding dis-

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tance from the source of injury. In the muscle bundles the hæmorrhage seemed to bulge the fibres out, which would account for the difficulty in replacing fractured ends some time after injury.

When this experimental fracture was examined ten days after injury there was overriding of the fragment and an extensive callus formation which surrounded the broken ends and extended well out into the muscles. It was

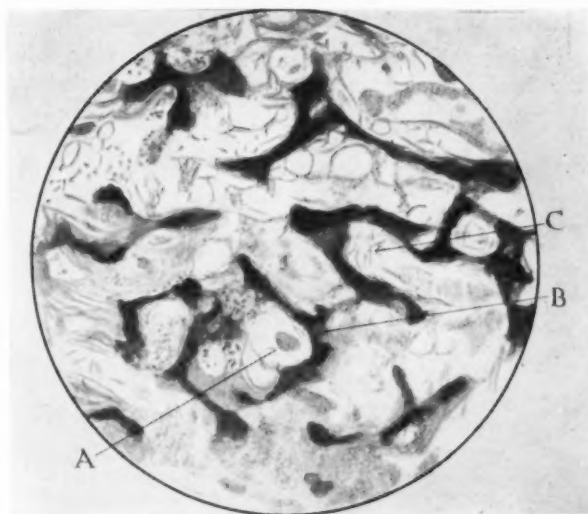


FIG. 2.—Artist's sketch of nine-day callus. Note arrangement of blood vessels, areolar tissue and callus. A, Blood vessel. B, Callus. C, Connective tissue.

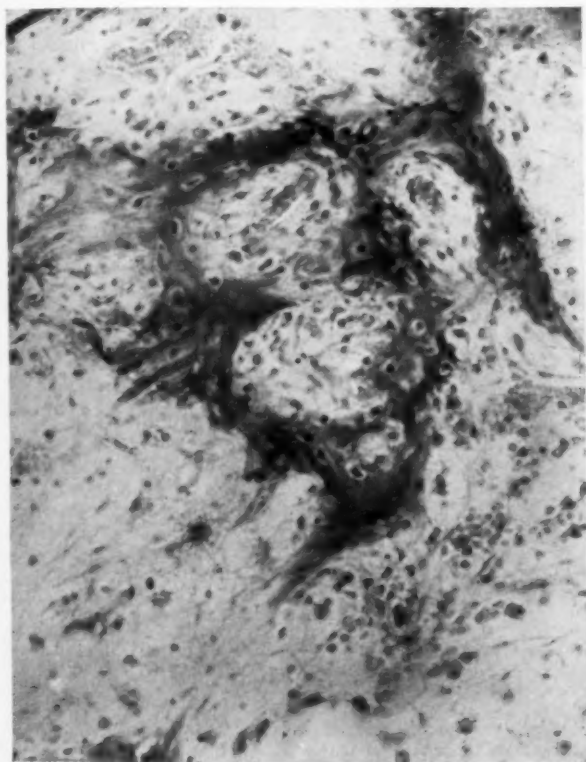


FIG. 3.—Photomicrograph of eleven-day callus. Note arrangement of blood vessels, areolar tissues and callus. The trabeculae tend to form about capillaries and the "bone cells" are apparently formed by the inclusion of fibroblasts in the bone-forming process.

possible to move the fractured ends in an angular zone, but even with the skin and surrounding muscles removed it was almost impossible to use sufficient force to bring the fractured ends in apposition and correct overriding.

This gelatinous consistency of the callus explains the difficulty experienced in attempting the late reduction of fractures under anaesthesia by manual traction.

On cutting this callus with a knife a distinct grit of the tissue could be felt. The areas where there had been hæmorrhage showed pigmentation and gradual absorption of the clot. Later



examinations revealed union with overriding and dense infiltrative callus.

*Microscopic Examination.*—Immediately after injury torn muscle fibres are seen with hæmorrhage extending out through the muscle bundles and following fascial planes.



FIG. 4.—Artist's sketch of twelve-day fracture, showing callus beneath the periosteum, penetrating the medullary cavity and extending outward toward the muscles. A, Periosteum. B, Periosteal bone. C, Cortex. D, Medulla. E, New bone, with haversian system at right angles to shaft.

the bone cells in the immediate vicinity. (Fig. 8.) There were also areas where decalcification had occurred and apparently small spaces formed in the bone. Surrounding the fractured ends there had been a definite ingrowth of tissue suggesting granulation tissue. The vessels ran in general at right angles to the cortex and apparently they had grown in from the periosteum and the muscle structures at the periphery and had also grown outward from the vessels in the medullary canal. A somewhat definite pattern was visible which suggested a structure almost comparable with the lobules of the liver. That is, one could see a blood vessel and around it an area of areolar tissue and beyond this at the periphery an area of deposition or secretion of osteoid material. (Figs. 2 and 3.) This osteoid tissue surrounded and incorporated the cells in its immediate neighborhood and it was always in the avascular areas. In places there were dense areas of cartilage cells in which there were irregular darker staining areas, apparently due to increased calcification. In the zones where cartilage, connective tissue and bone joined there was a gradual transition in the appearance of the cells. (Fig. 7.) It was impossible in these transitional zones to determine the exact character of the cell involved.

Some sections examined showed a surprising amount of free blood dissecting between the muscle bundles in the direct neighborhood of the fracture. Sections three to five days after fracture showed fibrin formation in the clot in the region of the fracture with connective tissue cells beginning to infiltrate the fibrin. Here and there could be seen small areas which stained more densely, showing beginning ossification. (Fig. 1.) Sections examined ten days after fracture showed rarefaction of the cortex in the neighborhood of the fracture with absence of nuclei in



FIG. 5.—High power view of curettings removed from a twelve-day old fracture of human femur. At the periphery of the section in the new fibrous tissue, remnants of striated muscle are seen caught in the callus. See Fig. 6.

## PROCESS OF UNION AFTER FRACTURE

This osteoid tissue surrounding the fracture zone often extended well out into the muscle bundles, and was seen transversing the zone between the fractured ends and through the medullary canal. (Figs. 4, 5 and 6.)

In sections taken three to four weeks after fracture, osteoid tissue was seen to be gradually assuming the characteristics of the haversian canal systems. The proliferation of the osteoid tissue occurred at the expense of the areolar tissue immediately surrounding the vessels. The exuberant callus had lost its osteoid staining characteristics and more closely resembled scar tissue. Where the periosteum had been stripped from the bone the vessels of the osteoid tissue ran at right angles to the long axis of the shaft.

Sections of linear fractures observed eight months to one year following fracture showed the reestablishment of the medullary canal

and the reestablishment of the normal alignment of the

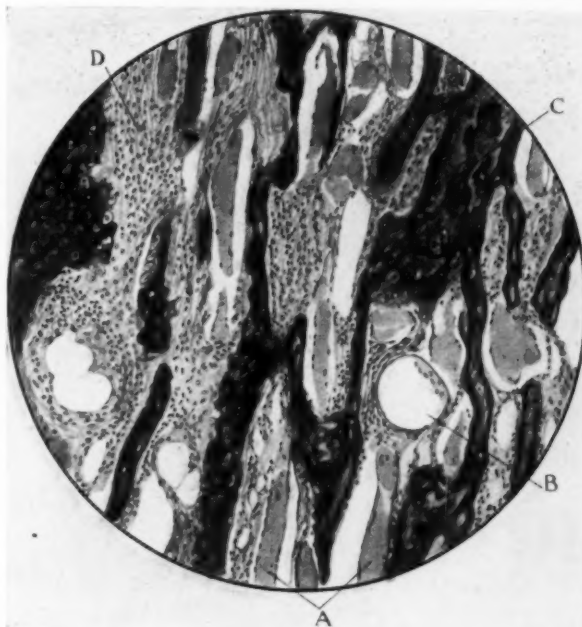


FIG. 6.—Artist's sketch of high power view of Fig. 5. Twelve-day human fracture. A, Muscle fibres. B, Blood vessels. C, Callus.

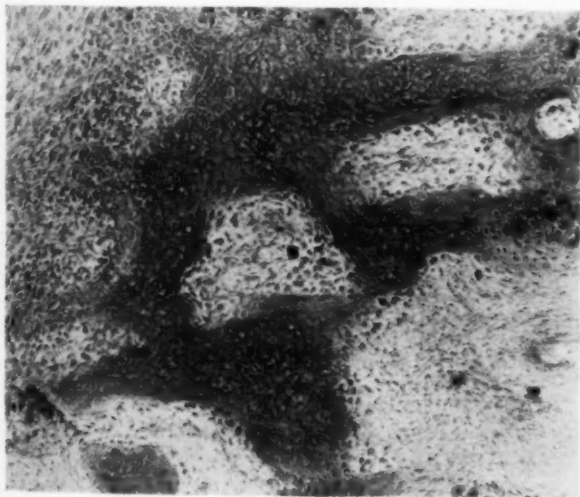


FIG. 7.—Fracture of dog's humerus, seventeen days. There was overriding of the fragments. Note gradual transition of connective tissue cells to bone cells.

shaft when proper reduction had been performed. The haversian canals in the fracture area ran at right angles to the shaft in contradistinction to the normal parallel arrangement of these canals. The reestablishment of the normal alignment of the haversian canals apparently proceeded by so-called creeping replacement.

In comminuted fractures where fragments had been entirely separated from their blood supply, no nuclei were observed at two weeks following fracture. At four to five weeks following fracture the haversian canals of these fragments contained blood vessels with apparently living red blood cells. Immediately surrounding these haversian canals one to two layers of bone cells with active staining nuclei were observed. Elsewhere no nuclei could be seen. (Figs. 10 and 11.)

At eight months to a year it is impossible to identify fragments on microscopic sections. Here and there areas of bone wherein the nuclei do not stain suggest the location of the bone fragments. It is reasonable to assume that these fragments have acted as an extensive source of calcium and that the vascular channels in these fragments have been utilized by the granulation tissue in the formation of the new bone.

I believe that the processes above described occur in fractures in the normal process of repair. We know these various stages. We do not know the origin of the cell that enters into the primary osteoid tissue. Various authors attribute the origin of this cell to: (1) Osteoblasts which are set free by the fracture; (2)



FIG. 8.—Artist's sketch of two-weeks' fracture in dog. Linear fracture, immediately treated. Note absence of nuclei in cortex and demineralization; ingrowth of callus perpendicular to shaft. A, Cartilage. B, Adjacent cortex, with destruction of nuclei. C, Callus. D, Normal cortex. E, Cyst formation in cortex—bone atrophy.

to cells arising from the periosteum and endosteum; and (3) to osteoblasts which arise by a process of metaplasia from fibroblasts.

Considerable work has been done in recent times to throw doubt on the existence in adult life of any specific cell having osteoblastic function.

I believe that too great importance has been placed on the nature of these cells, except from a standpoint of academic interest.

From a study of the repair of fractures in human subjects as well as in experimental animals it is my conviction that the future of the repair of a fracture depends almost entirely on the immediate local treatment that the patient receives and very little upon the systemic metabolism of the

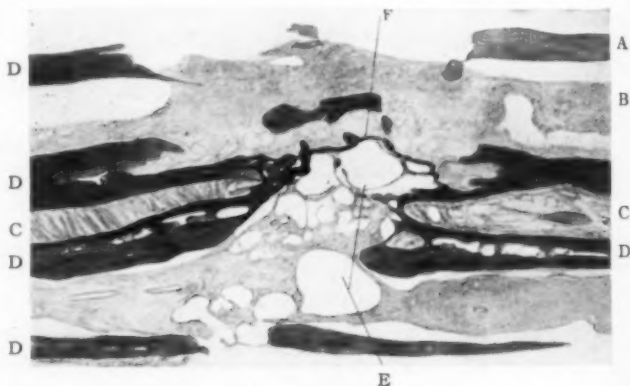


FIG. 9.—Three-weeks' fracture of radius and ulna in rabbit. Immediately treated by too tight circular plaster. Failure of repair. A, Cortex. B, Medullary canal. C, Interosseous membrane. D, Cortex. E, Cyst formation—failure of ingrowth of granulation tissue. F, Slight attempt at union.

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individual. That is, if a fracture is immediately treated in a manner which will replace as far as is feasible the fractured ends in suitable apposition and allow for the organization of the clot and the ingrowth of granulation tissue with its accompanying vessels, repair will inevitably follow.

Clinically, this means that if a fracture is so treated that there will be no constriction or obstruction to its blood supply and that there is sufficient immobilization to allow the ingrowth of granulation tissue without its being constantly broken up and interfered with by the movement of the rough fractured ends of bone, repair will proceed in an orderly manner.

### *The Things We Do Not Know About Bone Repair.*—1. We do not

know the origin or the function of the cells that enter into the primary osteoid tissue. Numerous experiments have been performed by transplanting periosteum alone, and bone without periosteum. These have been unconvincing because of necessity some bone would be attached to the periosteum and some endosteum lining

the haversian canals would be transplanted with bone fragments.

Bone may be produced experimentally in almost any part of the body. Microscopically it is bone, and grossly it resembles living bone. Neuhof, in experiments at Columbia University, found bone almost universally in fascia lata transplants which he had used to fill defects in the bladder. It would seem that any theory which accounts for bone repair must account for experimental and pathological bone. It is hard to account for experimental or pathological bone by any theory which presupposes that the osteoblast is a specific cell that must arise from either the periosteum or from part of the cortical bone. As bone is a connective tissue it would be more reasonable to



FIG. 10.—Comminuted fracture of dog's radius 141 days after injury. Note bone proliferation about fragment with union. Nuclei in fragment do not stain save in immediate vicinity of haversian canals. A, Bone fragment. B, Cortex near fracture zone. C, New formed bone about fragment.



assume that the so-called osteoblasts may be fibroblasts which, by metaplasia, are transformed into bone cells.

2. We do not know the particular activity of the bone cells. We are not certain, although we may surmise, what action the cell has upon the production of bone. It may so synthesize in its metabolism phosphorus and calcium, that it is transformed into the triple calcium phosphate—the main

mineral constituent of bone. On the other hand the cell may be a pacific agent and be caught in the precipitation of the calcium and phosphorus elements on the intercellular stroma of connective tissue.



FIG. 11.—High power view of fragment seen in Fig. 10. *A*, Fragment showing one layer of nuclei about haversian canals. *B*, Bone proliferation with union about fragment. Note gradual transition of cells and stroma in this callus.

Wells has stated that the mineral ash of areas of calcification and areas of ossification are the same; that there is a fixed proportion of carbonate to phosphate, of 15 parts by weight carbonate and 85 parts by weight of phosphate. Pauli and Samec have shown that calcium carbonate and phosphate are soluble in an albuminous solution in seven times or more the amount of their solubility in water, so that they could be transported in this form in the blood.

Wells believes that a salt known as tribasic calcium carbonophosphate is carried to the seat of fracture by the blood and is precipitated on account of the low carbon dioxide content in this zone.

Watt in recent studies of calcification and ossification has shown that in areas of calcification, where there are no cellular elements, deposition of the calcium salts has occurred in minute spherical bodies and crystalline masses as would physically occur in the deposition of minerals. In areas of ossification, however, he believes that, as the new bone has a homogenous appearance, it is physically impossible for it to be a straight precipitation. He states: "(1) Calcium phosphate and calcium carbonate show characteristic easily-identified shapes of particles when precipitated in colloids; (2) the bone salts are not present as discrete particles in bone, and even in rapidly-growing parts, show no evidence of being deposited by simple precipitation; (3) Barille has shown that calcium salts are transported to the bone in the form of a complex double salt, calcium carbon-phosphate; (4) evidence favors the view that the salts in bone are deposited by activity of the osteoblasts, as a secretory phenomenon."



## PROCESS OF UNION AFTER FRACTURE

It has been shown that calcium phosphate and carbonate may be carried by the blood stream in sufficient quantities to provide for ossification. Incomplete experimental work now being carried on at the College of Physicians and Surgeons of Columbia University would seem to afford the basis for the possibility that the source of calcium for fracture healing is essentially the site of fracture, and that the blood stream is not necessarily involved as a calcium source. The calcium in the skeleton is more or less in a position of flux. In certain cases of pancreatic fistulas and in breast milk it has been shown that calcium is utilized from the skeleton. X-rays of bone immobilized for any period of time show the demineralization which occurs from disuse.

It is well known clinically that a comminuted fracture produces more callus than a simple fracture. Experimentally if the comminuted fragments in such a fracture in a dog are removed, boiled, and replaced, union occurs in normal time and normal manner. If the fragments, on the other hand, are decalcified before replacing them fibrous union occurs, but no calcification of the stroma takes place.

In our studies of the ends of bones in the region of fracture there is sufficient evidence to warrant the belief that the calcium necessary for the callus may be taken from the immediate vicinity of the fracture.

Colloidal combination or involved inorganic calcium compounds have been presumed by the majority of experimental workers as the form in which calcium exists in the bone or in the blood stream. It is suggested that calcium and phosphorus in the bone or blood stream may exist as an organic compound of tremendous molecular size, and they are allied with a carbohydrate radical, such as a calcium hexose phosphate. Such a combination might be split off from the tremendous molecule of which it is a part by the activity of a hexose-splitting ferment. The latter might be the product of a specific osteoblastic cell, or might be freed by the death of connective tissue cells of any non-specific type. Such ferment activity would be markedly affected as to its rate by relatively slight changes in the  $P_H$  of the surrounding medium. Bone formation, whether the result of fracture, chronic soft part disease, or of experimental efforts, is invariably accompanied by both qualitative and quantitative circulatory changes. Here is a factor which might be used to explain local changes in the  $P_H$  of the tissues at the site of bone production, sufficient to account for the variation in the degree of activity of any hexose-splitting ferment such as has been described above. The work on this phase of the question is at present in a rather chaotic state and the matter presented here is to be viewed in the light of possibilities which have aroused considerable thought.

Let us now see if we can clinically adjust a working hypothesis for the treatment of fractures, from conclusions drawn from the things we know and from the things we surmise in the treatment of fractures. The most important factor for the union of fracture is to have the fractured ends in close apposition and to have an adequate blood supply to allow the ingrowth of

granulation tissue with the resultant ossification to form callus. It appears, therefore, that the clinical handling of a fracture should be centred more upon the local and immediate treatment of the injured limb than upon the general metabolism of the individual. In rickets, which is perhaps one of the most noticeable metabolic diseases of bone, non-union after fracture is a relative rarity.

It is not our purpose to neglect the treatment of the patient. Obviously fresh air, sunlight, good food and, later, physiotherapy are important adjuncts in the general treatment of the individual. It is, nevertheless, the purpose of this paper to stress that the immediate local treatment of the injury is the most important factor in the cure of the individual.

*Clinical Deductions from a Study of Bone Repair.*—1. The ideal treatment of a fracture should be the replacement of the fractured bone in as nearly perfect apposition as is possible. Union occurs with less output of callus and therefore less infiltration of the surrounding muscles where the periosteum is broken. When apposition is mechanically perfect there is consequently less interference with muscular activities.

2. The immediate replacement of fracture is advisable because several hours after fracture the swelling due to hæmorrhage which infiltrates the muscle bundles is so excessive that replacement becomes difficult. Overriding is difficult to correct because the longitudinal fibres of the surrounding muscles are so ballooned-out by the hæmorrhage that sufficient extension for replacement is almost impossible without creating greater trauma. Often extremities have to be suspended for several days in order to allow subsidence of the swelling before reduction can be attempted. As a result primary granulation tissue is interfered with and non-union may result.

3. Our primary effort in the treatment of a fracture must be to allow adequate circulation. Robinson has shown that, "since muscle is in a colloidal solution, albeit retained in its form by its sheath or its other fibrous interstitial structures it will have the physical characteristics of a fluid. The pressure in and about muscles is greatly increased by the trauma and resultant hæmorrhage. This pressure may be resisted by heavy layers of tissue and by tightly applied splints, bandages and adhesive plaster or cases. If resistance to expansion occurs, its effect will be to diminish or occlude the lumen of the arterial blood vessels, and thus prevent an adequate supply of blood from reaching the fracture zone." If this persists for any period of time granulation tissue is readily transferred into scar tissue, which is the worst enemy of union.

4. In cases where reduction is not attempted for several days the gelatinous consistency of the callus interferes with the manual correction of overriding. Only long-continued traction may correct the deformity.

5. Operative treatment of fractures: The ideal for operative treatment of fractures should be accurate replacement of fractured ends with the least possible trauma to the surrounding parts and the introduction of the smallest possible amount of foreign body to maintain replacement. Immobiliza-

## PROCESS OF UNION AFTER FRACTURE

tion by external means, such as splints, cases, etc., must be so applied that the resultant swelling will not interfere with the necessary blood supply.

(a) Internal fixation of fractures by bone grafts: In order to have a successful graft three conditions must be met; first, the graft must maintain the shape of the limb; second, it must have its blood supply quickly reestablished; and, third, it must stimulate osteogenesis in the neighboring tissues. In general, the smaller the graft the more apt it is to stimulate osteogenesis about it, and the more likely it is to have its blood supply quickly reestablished. McWilliams, in a thorough analysis of the various methods of bone grafting, read before the American Surgical Society in Toronto in June, 1921, came to the conclusion that the presence of periosteum upon the graft had very little influence upon its ultimate success. He analyzed about 1390 cases in which grafts had been used. Of these, 1170, with 82.0 per cent. of successes, had periosteum, while 196, with 82.6 per cent. of successes, were without periosteum. Clinically, it would seem more rational to transplant the graft with periosteum attached because vascular adhesions of connective tissue to connective tissue (connective tissue of the host with connective tissue of the periosteum) probably occur quicker than the vascular adhesions of connective tissues and bare bone.

(b) Where foreign bodies, such as plates or screws or nails, are introduced to maintain a fracture in apposition by operative means, osteogenesis is inhibited in their immediate neighborhood. If operative treatment of fractures is to reach its ideal it must perfect these mechanisms. In fractures of the radius and ulna the relative size of the foreign bodies introduced to maintain alignment are frequently out of proportion to the size of the bone. It is the belief of the author that non-union occurs too frequently from this type of treatment because osteogenesis is interfered with to too large an extent. Surgeons seeking ideal results must devise an improved operative technic for this type of injury.

(c) Fractures in children differ essentially from those in adults in that anatomical displacements of fractured ends often unite without resultant deformity. In children, bone is much more pliable than in adults and fractures occur when bone growth is active. The studies of late results show that often where there has been overriding of at least one inch, X-rays taken several years later show no shortening and it is often impossible to see the line of fracture. If we bear these facts in mind many unnecessary open operations on children will be avoided.

6. The problem of non-union is not discussed in this paper for the reason that Cowan gave an excellent presentation of this subject at the last meeting of this Association. The author agrees with his findings, except perhaps in some minor academic details.

## IS ACCURATE REDUCTION OF A FRACTURE NECESSARY?

By ASTLEY P. C. ASHHURST, M.D.

OF PHILADELPHIA, PA.

THE question that has been assigned me by the committee on this fracture symposium bears a certain resemblance to that popular but unanswerable question of not so many years ago, namely, "How old is Ann?" It is a question that cannot be answered without some preliminary limitation and definition. On the face of it, two obvious answers present themselves: Is accurate reduction necessary? (1) of course! and (2) of course not!

It becomes my duty, then, to attempt to define which fractures do, and which do not, require accurate reduction. And it is, of course, first necessary to have a clear understanding of what is meant by "accurate reduction." I think we must all agree that it means anatomical restitution of the fragments to the position they occupied before the fracture occurred; and their maintenance in that position until consolidation has taken place. This is what our Fracture Committee in 1915 understood by the term "good anatomical result." (*Trans. Amer. Surg. Assoc.*, vol. xxxiii, p. 784, 1915.)

### MEANS BY WHICH ACCURATE REDUCTION MAY BE SECURED

1. *Manipulation and locking of the fragments* may be attempted, usually with the patient anæsthetized, in such fractures as are more or less transverse, and in which it is evident that the fractured surfaces can be kept in apposition either by the aid of splints, or by means of the position in which the limb is dressed. This method applies especially to such injuries as supracondylar fractures of the humerus, fractures of the radius above the wrist ("Colles"), fractures of the neck of the femur (intracapsular), and most fractures around the ankle. It is more difficult to secure reduction by manipulation in fractures in the shafts of long bones than it is in fractures near joints, and even if secured, it often is impossible to maintain it by position or by splints.

2. *Open reduction with or without internal splints* may be attempted when efforts have failed to secure reduction by manipulation and locking of the fragments. In some cases, in which it is well known that attempts at closed reduction usually are unsuccessful, resort may be had at once to open reduction. Such, I believe, are cases of fracture of the shaft of the radius, the ulna being intact, and the fragments of the radius being transposed—by which I mean that the fractured surfaces do not face each other, but are placed back-to-back, so that union probably will not occur.

After reduction has been secured by open incision, I believe the use of an internal splint usually is desirable, unless the fragments are so shaped that they are very firmly locked, and unless the surgeon is very sure of being able to maintain reduction by his external splints and dressings.



### IS ACCURATE REDUCTION OF A FRACTURE NECESSARY?

3. *Continuous traction until consolidation* is a method of securing and maintaining reduction adapted to fractures whose fragments are of such a shape, or so much comminuted, that they cannot be locked in position even after reduction has been secured. It is the method of treatment which I find particularly suitable for fractures of the shaft of the femur, and of the shaft of the humerus. In the femur, weight traction is used; but in the humerus the force of gravity usually is sufficient both to secure fairly accurate reduction and to maintain it, the patient being ambulatory, and the wrist only (not the elbow) supported by a sling. Of course, in both cases suitable coaptation splints are employed also; and in cases of fracture of the shaft of the humerus care must be taken not to allow overcorrection of the shortening to occur, since this favors delayed union or non-union. In most fractures of the leg and ankle I find the Delbet method entirely satisfactory both for reduction and retention; reduction is secured by continuous traction (without manipulation) in a very few minutes, and is then maintained by accurate adjustment of moulded plaster-of-Paris splints. (Ashhurst and Crossan: *Trans. Amer. Surg. Assoc.*, vol. xli, p. 594, 1923.)

#### DISADVANTAGES AND DANGERS OF REPEATED ATTEMPTS TO REDUCE

Reduction should be secured within a few hours of the injury; at this time it usually can be secured without difficulty. If the surgeon postpones reduction, he finds it increasingly difficult to secure, because the reparative processes of nature will not wait on his convenience. Delayed and, especially, oft repeated attempts at reduction not only do great injury to the soft parts, but are quite apt to hinder the progress of union, with the result of delayed union, or even of non-union. Water which is constantly agitated will not easily freeze.

Union is the first desideratum: malunion is less of an evil than non-union; though of course firm fibrous union in good position may give the patient a more useful limb than monstrous deformity with bony union. I have in mind an aviator during the German War, who had firm fibrous union in a fracture of the humerus, without any deformity. He continued active flying for many months under the belief union was bony, and with no disability, finally coming under my care at the Walter Reed General Hospital for refracture which was shown at operation to have occurred not through bony union, but through fibrous union. I have also seen more than one patient with only fibrous union of the shaft of the radius, with angular motion easily detectable while the muscles were relaxed, but which when splinted in the midst of a tightly contracted muscular mass become as rigid as iron. But, I repeat, malunion of moderate degree is less of an evil than non-union; and I unhesitatingly declare that it is better to leave almost any fracture without accurate reduction than to secure the latter only at the expense of firm union.

I know that there are some who will regard this as pernicious teaching, and who believe it is dangerous to let it be known that anything short of



accurate reduction ever can be satisfactory. But I am here to tell the truth, and I cannot believe that the truth on such a subject as this can do any harm.

*What degree of reduction is sufficient?* The answer to this question depends upon (a) the site of the fracture; and (b) the age of the patient.

In general terms it may be stated without fear of contradiction that those fractures which do well even without accurate reduction are those that occur *in the shafts of the long bones* (some distance from the joints), and *in the young*, especially those under six or seven years of age. These limits may even be extended in individual cases: (1) Fractures near to joints do not always require accurate reduction in the very young; (2) even in some adults accurate reduction is not necessary in some fractures of the shafts of long bones. For, after all, what we aim to secure is return of function; and it is an undisputed physiological law that form depends upon function, and not function on form. The bones of the young are capable of vigorous

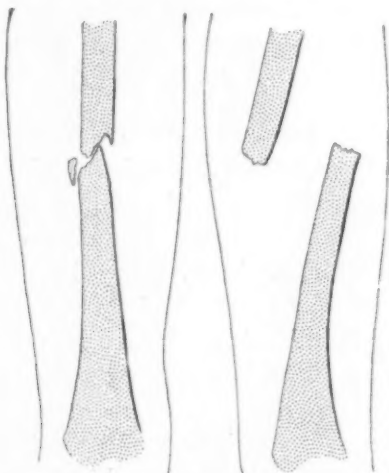


FIG. 1.—Case I. Milton Gunson, seven years. Fracture of shaft of femur. X-rays after attempts to reduce under anesthesia. Open reduction planned. Ward placed under quarantine for scarlatina. No operation. See Figs. 2 and 3.



FIG. 2.—Case I. Two months after injury. Callus bridges the large gap. Firm union.

growth and remodeling, in response to the call of function; and it has been shown by Ridlon,\* Truesdell (*ANNALS OF SURGERY*, vol. lxxiv, p. 498, 1921; *ibid*, vol. lxxxviii, p. 909, 1928), and others that accurate reduction may be actually detrimental in fractures of the shaft of the femur in childhood, resulting in eventual lengthening of the limb. If the fragments had been left with a very little overlapping in the first place, the subsequent overgrowth, due to the stimulation from the injury, would merely have equalized the length of the limbs, and would not have made the fractured bone longer than normal. For many years, in cases of fractures of the diaphysis, I have been satisfied with approximate reduction. So long as bony union is secured,

\* Ridlon (*Amer. Jour. Orth. Surg.*, vol. vii, p. 522, 1909): Two and one-half years after open reduction of a fracture of the femoral shaft in a girl eight years of age, the limb was two and one-quarter inches (6 centimetres) too long.

# IS ACCURATE REDUCTION OF A FRACTURE NECESSARY?

and the shortening is inappreciable, and so long as the axes of the fragments are restored nearly to normal, I have never yet failed to secure com-

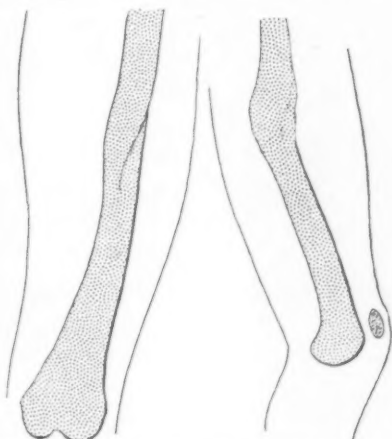


FIG. 3.—Case I. Six months after injury. Normal function for last two months.



FIG. 4.—Case II. Ruth Ross. Fracture of shaft of femur in an infant three months old. From X-ray made sixteen days after injury. Union with right-angle deformity.

plete return of function, and in children eventually a restitution nearly of the normal form.



FIG. 5.—Case II. Six years later. Before the child was old enough to walk spontaneous correction of the deformity had occurred.

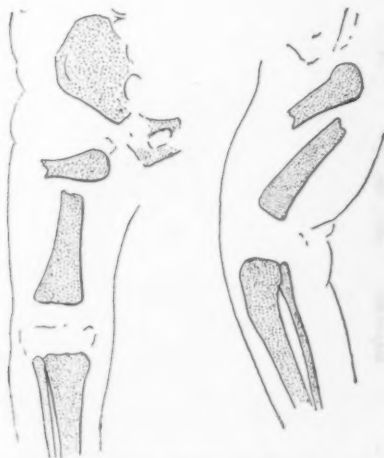


FIG. 6.—Case III. Bennie Sherwin. Fracture of shaft of femur during obstetrical delivery. Position of fragments after dressing.

CASE I.—M. G., boy, seven years of age; simple fracture of shaft of femur; run over by wagon November 1, 1914. Condition of soft parts bad. X-rays after attempted reduction under anæsthesia are shown in Fig. 1. On account of the wide separation of the fragments shown in the lateral view, I feared non-union, in spite of the patient's youth. Operation was planned, but could not be done owing to an outbreak of scar-

latina in the ward. I found four weeks later that some union was apparent, and that there was only 0.5 centimetre shortening; while two months after the accident X-rays (Fig. 2) showed callus bridging the large gap. The bones rounded off, and normal function was secured about four months after the injury (Fig. 3). (Reported in *Amer. Jour. of Surg.*, vol. xxix, pp. 114, 132, 1915.)

CASE II.—It was the memory of the result in Case I that authorized me to give a very favorable prognosis in the patient whose fracture is represented in Figure 4.



FIG. 7a.—Case III. At age of three and one-half months. Anteroposterior view.

the parents and their physician were satisfied; and three and one-half months later were pleased to see Figures 7a and 7b, showing that the growth of the limb had spontaneously straightened the femur.

Fractures near to, or involving, joints require accurate reduction almost in all cases, even in children; because even in the young malunion of a

The mother had fallen with the infant (three months of age) in her arms. When first seen (November 20, 1915), three days after the injury, there was tenderness and swelling of the already very fat thigh, but no crepitus nor abnormal mobility was noted. The baby was treated by flexing the hip and bandaging the thigh to the abdomen. The röntgenogram, a tracing of which is shown (Fig. 4), was made sixteen days after injury. Union had occurred with right angle deformity. Six years later, in 1921, I secured the röntgenograms shown in Figure 5. Before the child was old enough to walk spontaneous correction of the deformity had occurred.

CASE III.—A baby had its femur fractured during delivery (1923). A skillful surgeon applied a very neat little plaster-of-Paris dressing to the fractured limb and pelvis; but the accoucheur after seeing the röntgenogram (Fig. 6), showing right angle deformity and overlapping, brought the baby to me for my opinion, fearing the deformity would result in disability. On my positive assurance that there was no cause for worry,

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joint fracture very frequently causes restriction or loss of joint motion; and even if normal range of movement is preserved, distortion of the axis often is encountered (*varus* or *valgus* deformities in fractures at the elbow). (Figs. 8 and 9.) But sometimes, even in fractures near joints, nature will obviate by growth a deformity which the surgeon leaves uncorrected.

CASE IV.—H. K., fourteen years of age, who was admitted to the Episcopal Hospital August 14, 1928, presented an impacted fracture of the right radius, above the wrist, with

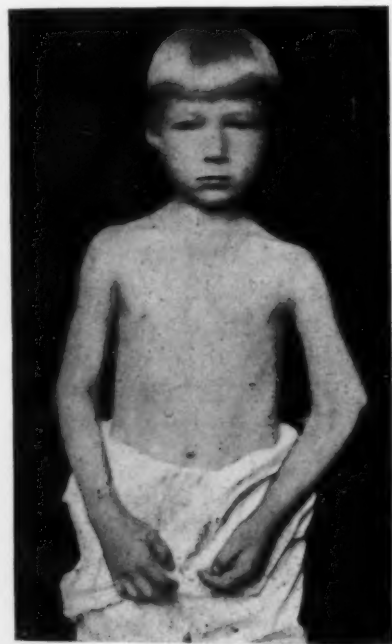


FIG. 8.—Cubitus varus, following use of anterior angular splint for supracondylar fracture of humerus.



FIG. 7b.—Lateral view.

marked angulation due to dorsal displacement of the lower fragment; he had also a greenstick fracture of the ulna at the same level. (Figs. 10a and 10b.) The boy had also a fracture of the calcaneum, which confined him to bed. The forearm fracture was purposely left unreduced, being lightly dressed on a straight splint, in the confident expectation that spontaneous reduction would occur from normal growth of the bones. Figure 11, from a roentgenogram made seven weeks after the injury, shows that this actually occurred; and Figure 12, from photographs I made five weeks after the injury, shows even at this early date very nearly normal function.

CASE V.—H. S., eight years of age, came to my clinic at the Orthopaedic Hospital September 20, 1927, four weeks after a fall on the point of her elbow. She brought with her X-ray pictures made at the time of the injury (Figs. 13a and 13b), August 23, 1927; these showed a diacondylar fracture of the humerus by flexion, the condylar fragment being displaced forward into the bend of the elbow, but still in contact with the shaft fragment. I advised no treatment, and asked the girl to return in a year. At this time roentgenograms (Figs. 14a and 14b) showed an entirely normal elbow-joint, and the clinical result was perfect, anatomically and functionally. Had the lower

fragment been displaced backward in this child, as in the typical supracondylar fracture "by extension," it is not likely though possible, that full range of movement would have been secured without accurate reduction; if the condyles had been displaced laterally or medially, the child almost certainly would have recovered with a deformity of cubitus valgus or varus, as in Fig. 9.

In adults it is more important to secure accurate reduction than in children, because adults are unable to remodel their bones to compensate for uncorrected deformities

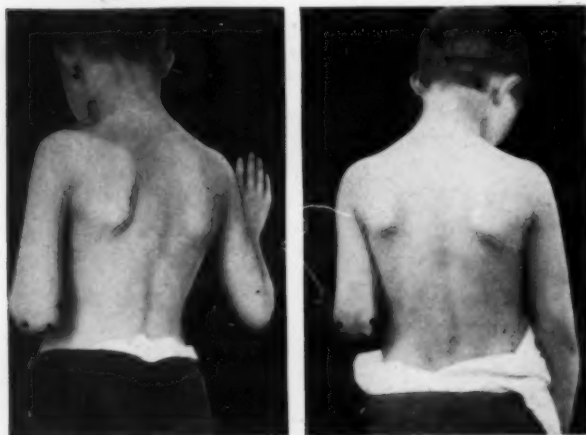


FIG. 9.—Cubitus varus following supracondylar fracture of humerus. (a) Before operative reduction of malunion. (b) After operation. Note the dots on the external and internal condyle and on the olecranon. (This case was reported in ANNALS OF SURGERY, vol. lvi, 1912, p. 647, Case III.)

in the remarkable manner exemplified in the case histories of children which I have just quoted (Cases I, II, III, IV and V). But even in adults very little if any disability will result from lack of accurate reduction of a fracture in the shaft of a long bone, provided (1) bony union is secured; (2) the axes of the fragments are preserved, without angulation and without rotation of one frag-

ment on the other; and (3) the shortening does not exceed one centimetre.

Distortion of the axes, or rotation of one fragment on the other, usually entails disability at least to the extent of pain and soreness in damp weather or after arduous labor. This discomfort is more often experienced in a neighboring joint than at the seat of fracture. The latter, indeed, seldom gives rise to distress even if grossly deformed unless bony union is absent or unless the functions of the soft parts are involved. The joint symptoms are due to disturbances in the weight-bearing axes, bringing strain on the ligaments, and provoking arthritic reactions in the form of exostoses and osteophytes. These joint changes are most to be feared in the knee or the ankle, after fractures of the shaft of the tibia and fibula. Both the knee and the ankle are hinge-joints, accustomed to working in the same plane; and any rotation of one tibial fragment on the other at once throws these two important hinge-joints out of alignment. In fractures of the femur and of the humerus, compensation for slight rotatory deformity may be brought about through the medium of the hip or of the shoulder-joint, by which means the proximal fragment can be rotated until the distal fragment is brought into the most useful plane. Neither the ankle or the knee-joint possesses the function of rotation, and therefore no way exists of compensating for rotatory deformity in the tibia.



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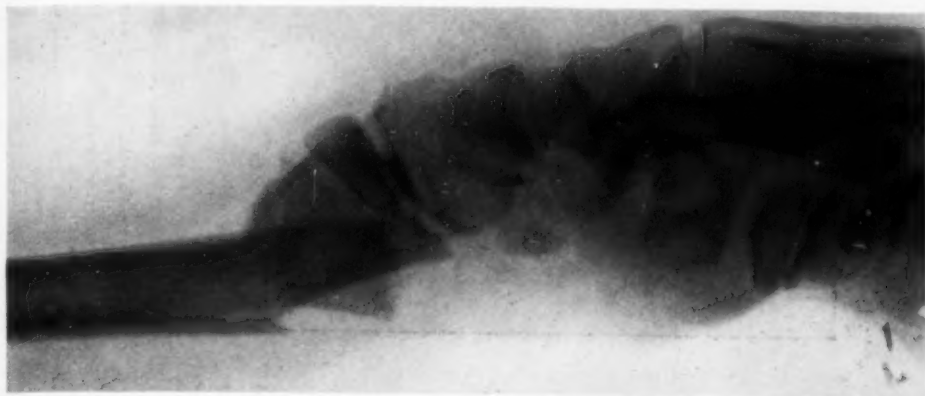


FIG. 10a.—Case IV. Henry Kuerf, four-  
teen years. Fracture of radius and ulna just  
above wrist, with marked displacement of  
radial fragments, which were purposely left  
untreated.



FIG. 10b.—Anteroposterior view of lesion  
shown in Fig. 10a.

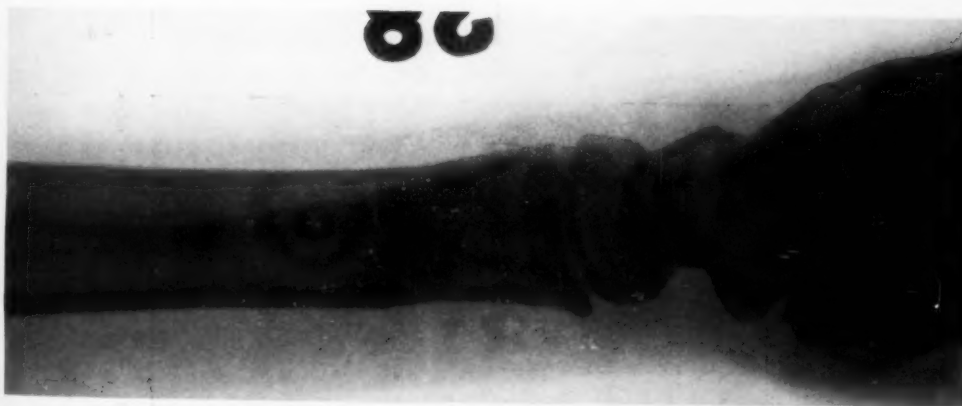


FIG. 11a.—Case IV. From X-ray seven  
weeks after injury, showing spontaneous re-  
duction of deformity.

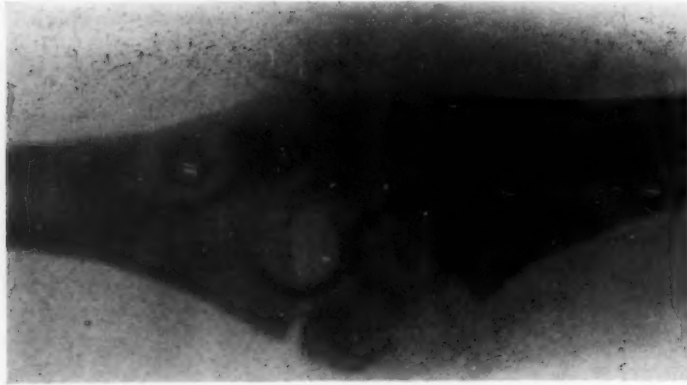


FIG. 13a.—Case V. Helen Smiler, eight years. Skiagraphs made August 23, 1927, of recent diaphyseal fracture of left humerus with forward displacement of lower fragment, but without medial or lateral displacement. Anteroposterior view.



FIG. 12.—Case IV. Photographs made five weeks after injury, showing even at this early date very nearly normal function. Was accurate reduction necessary?

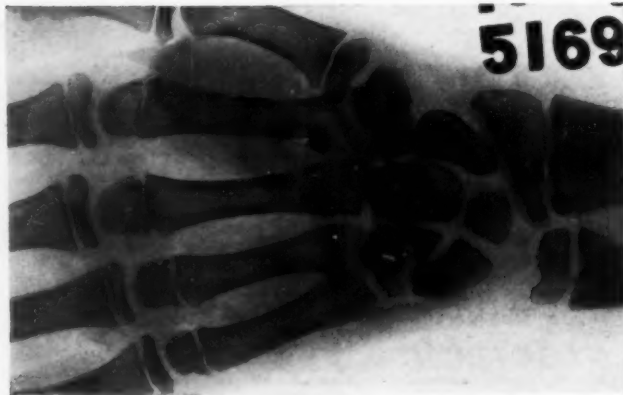


FIG. 11b.—Anteroposterior view of wrist shown in Fig. 11a.

## IS ACCURATE REDUCTION OF A FRACTURE NECESSARY?

Much more harm than good often is done by insistence on securing accurate reduction of a shaft fracture in an adult.

**CASE VI.—Accurate Reduction of a Fracture of Shaft of Femur; Stiff Knee. Out of work eighteen months.** F. C., twenty-four years of age, came to my clinic at the Orthopaedic Hospital October 9, 1928, complaining of immobility of his right knee. The shaft of his right femur had been fractured September 7, 1927; he also sustained a fracture of the skull and a fracture of the right ulna. Because of failure to secure accurate reduction of the fracture of the femur, open reduction, with fixation of the

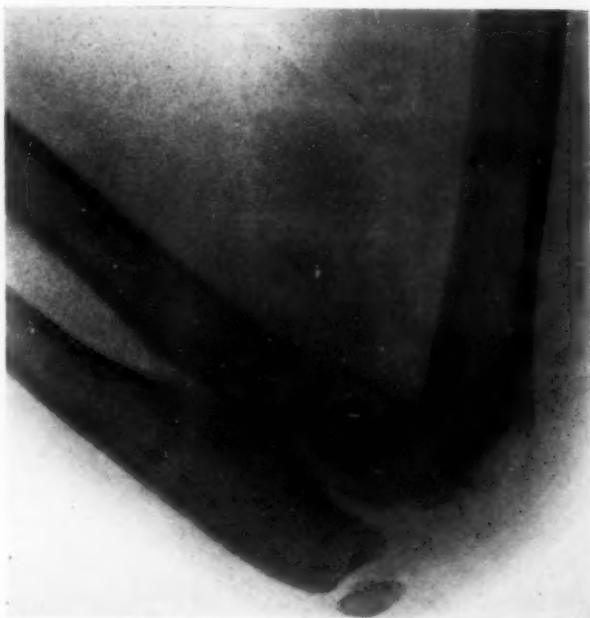


FIG. 13b.—Case V. Lateral view. First seen three weeks after injury. No treatment advised.



FIG. 14a.—Case V. One year later, showing spontaneous correction of deformity. Perfect function was present.

fragments by wire, had been done October 26, 1927, seven weeks after the injury. The operation had been done through a mid-line anterior incision, splitting the quadriceps muscle and the quadriceps bursa; and in order to secure end-to-end apposition, the bone ends were resected. The anatomical reduction was accurate (Fig. 15), but the bone had been shortened by two centimetres and union was slow in developing, some infection of the wound having occurred. He spent ten months in the hospital where his recent injury was treated, being discharged with a brace on the limb, and walking with a cane. Three months later, when he first came under my care, he had only twenty degrees of motion in the knee-joint ( $160^{\circ}$  to  $180^{\circ}$ ), and marked atrophy of the thigh muscles. The limitation of movement evidently was due to adhesions between the quadriceps and the underlying bone (not an unusual occurrence when an anterior mid-line incision is used). This patient spent four months in the Orthopaedic Hospital, where (October 18, 1928) I loosened the quadriceps from the femur through a lateral incision, removing the wire from the femur, and implanting between the bone and the muscle a large free transplant of fascia lata. The knee was dressed in acute flexion, in plaster-of-Paris; when the gypsum dressing was removed, the knee was brought gradually into extension up to  $150^{\circ}$ , the

final  $30^{\circ}$  ( $150^{\circ}$  to  $180^{\circ}$ ) being secured by forcible extension under an anæsthetic (January 2, 1929).

The range of motion finally secured after four months of effort was  $90^{\circ}$ . How much better it would have been not to have sacrificed nearly eighteen months of this young man's life, in the pursuit of "accurate reduction."

CASE VII. — *Inaccurate Reduction of a Fracture of the Shaft of the Femur; Good Function. Out of work five and one-half months.* W. K., sixty years of age, was admitted to my care in the Episcopal Hospital September 8, 1928, having just fractured his right femur at the junction of the middle and lower thirds. Shortening measured three centimetres. Buck's extension apparatus was applied at once, with a sliding leg splint to overcome friction, and coaptation splints of binder's board to the thigh. Fifty



FIG. 14b.—Lateral view of bones shown in Fig. 14a.

pounds (23 kg.) of weight were employed, the foot of the bed being raised, and counter-traction being made by a folded sheet passed around the perineum and fastened to the head of the bed. Measurements three days later showed lengthening on the injured side of 1.5 centimetres. The weights were gradually removed, until on September 20, twelve days after injury, only twenty pounds (9 kg.) remained. From September 28 to October 2, 1928, the patient passed through an attack of acute cholecystitis, making a satisfactory recovery without operation. On October 11, less than five weeks after injury, the callus was palpable, and union was firm; shortening measured not more than 0.5 centimetre. October 20, six weeks since injury, all weights and dressings were removed; the patient voluntarily raised his entire injured limb from the bed, and waved it around in triumph. October 27, seven weeks after injury, the old man was discharged, walking with crutches, and with active movement of the knee from  $150^{\circ}$  to  $180^{\circ}$ .

FIG. 15a.—Case VI. Frank Conrad, twenty-four years. One year after fracture of shaft of femur. Open reduction had been done seven weeks after injury, requiring resection of bone ends. Result: accurate reduction, two centimetres shortening, stiff knee. Out of work eighteen months.



February 10, 1929, I visited the patient at his home. He discarded his crutches soon after leaving the hospital, and secured right angle flexion of his knee ten weeks after injury. When visited, his knee could be flexed to  $70^{\circ}$  or  $60^{\circ}$ ; he walked spryly, without any limp, and complained only of some soreness in both knees in damp weather.

He resumed his work, which involves standing



FIG. 15b.—Lateral view in Case VI.

# IS ACCURATE REDUCTION OF A FRACTURE NECESSARY?

Fig. 16.—Case VII. William Kohler, sixty years. Fracture of shaft of femur on admission, September 9, 1928.

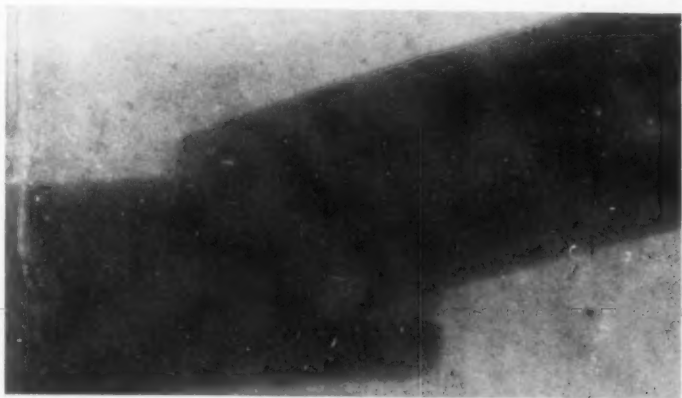
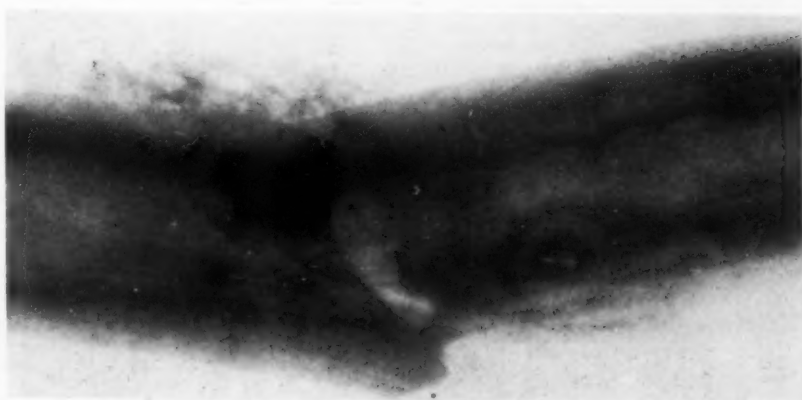


Fig. 17a.—Case VII. Six weeks after injury. Union firm. Walking with crutches seven weeks after injury.



Fig. 17b.—Case VII. Out of work five and one-half months. Was accurate reduction necessary?





X



FIG. 19b.—Lateral view, showing wide separation of fragments, and rendering occurrence of union very doubtful. Note X opposite end of upper fragment. (See Figs. 18 and 20.)



FIG. 19a.—Mary Kelly, forty-nine years, after attempted reduction under anesthesia. Anteroposterior view, good alignment.



FIG. 18.—Mary Kelly, forty-nine years. Spiral fracture of shaft of humerus; on admission (December 28, 1916), showing transposition of fragments. Reduction indicated. (See Figs. 19 and 20.)

# IS ACCURATE REDUCTION OF A FRACTURE NECESSARY?

FIG. 20.—Mary Kelly, forty-nine years. After open reduction and fixation by Farham bands. Perfect function. Out of work ten weeks.



FIG. 21a—Fracture of surgical neck of humerus on admission.

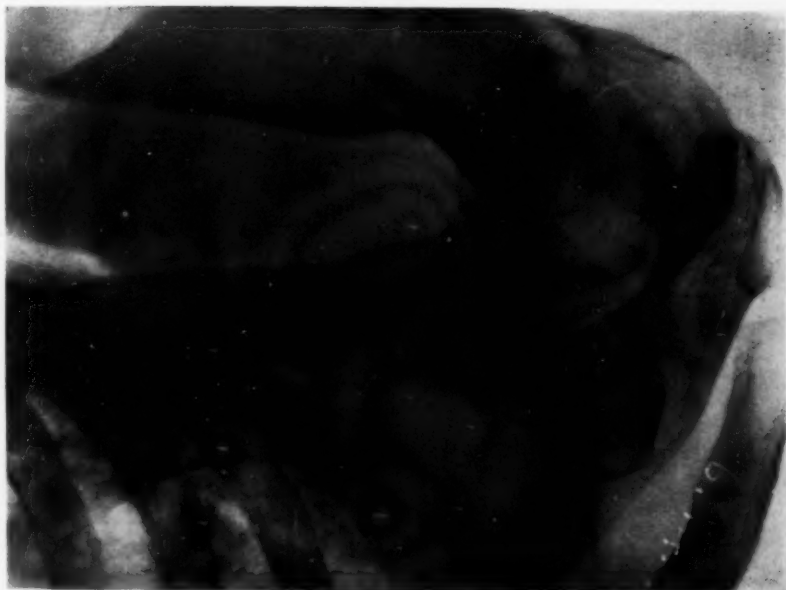




FIG. 22*b*.—Anteroposterior view, showing cubitus varus. (See Figs. 23 and 24.) (The nails shown are in the wooden splint.)



FIG. 22*a*.—Joseph Kennedy, twenty-two years. Comminuted fracture of lower third of humerus, on admission, August 14, 1915. Inaccurate reduction might impair function of elbow-joint. Lateral view on anterior angular splint.



FIG. 21*b*.—After being dressed in abduction in bed.

## IS ACCURATE REDUCTION OF A FRACTURE NECESSARY?

eight or nine hours daily in a mill, less than six months after injury.

Figure 16 shows the bone at the time of admission; and Figure 17 the appearance seven weeks later when he was discharged.† Was accurate reduction necessary?

But when the fragments in a shaft fracture are *transposed*, so as to make the certainty of union doubtful, earnest efforts should be made to secure reduction. (Figs. 18, 19, and 20.)

Joint fractures in adults, as a rule, require accurate reduction for preservation of function. Yet there are exceptions even to this rule. The mobility of the scapula on the trunk may very largely compensate for limitation of motion in the shoulder-joint following inaccurate reduction of a fracture of the surgical neck of the humerus; but it is certainly better to spare no effort, within reason, to secure



FIG. 23.—Joseph Kennedy, two months after open reduction and fixation by Lambotte plates and encircling wires. (See Figs. 22 and 24.)



FIG. 24a.—Joseph Kennedy. Three weeks after operation, in plaster-of-Paris dressing.

accurate reduction of a fracture of the surgical neck of the humerus rather than trust to the uncertain results which follow inaccurate reduction. (Fig. 21.)

Disabilities following fractures about the elbow-joint, in adult life, are serious and lasting. (Figs. 22, 23 and 24.) Worthy of note in this connection are fractures of the head or neck of the radius, as well as fractures of the external condyle of the humerus, which latter too often result in non-union (from lack of accurate reduction and sufficiently pro-

† The femur, in the opinion of Doctor Bromer, shows röntgenologic evidence of an early stage of Paget's disease.

longed immobilization), to be later complicated by ulnar palsy due to the gradually developing cubitus valgus.

Fractures of the lower end of the radius frequently cause lasting disability if left unreduced. It is true that a great many patients secure perfect function without complete reduction of the deformity. My father was one of those surgeons who held (and I believe rightly) that function is more important than form; and when he himself had the misfortune to fracture his left radius above the wrist (about 1885) he sent for Dr. Charles B. Nancrede to attend him. Doctor Nancrede told me in after years that when he arrived he found my father sitting on the lounge in his office, and was greeted with the admonition that he needn't try to reduce the deformity, that the patient himself would apply the compresses, and all that Doctor Nancrede would need to do, would be to bandage a Bond splint in place over these



FIGS. 24b and c.—Eight months after operation showing restoration of function. Plates and screw still in place fourteen years after operation.

compresses. Doctor Nancrede was criticised by another Fellow at a later meeting of this Association (*Trans. Amer. Surg. Assoc.*, vol. x, pp. 69, 75, 1892,) for having allowed his patient to recover with deformity; but he was able to retort that my father had operated for cleft palate just six weeks after he fractured his radius; and I can myself testify that he very soon resumed piano-playing with his accustomed brilliance and that he never had the least disability from the slight deformity which remained. There is still with us another Fellow who has carried since early youth a very conspicuous "silver-fork" deformity in each wrist, but who has pursued without disability for many years an extremely active career as operating surgeon. But these exceptions do not, I believe, impugn the general rule that in adults, even more than in children, accurate reduction is desirable in fractures near joints.

It is perhaps unnecessary that I should dwell further on this point, or that I should allude specifically to the importance of accurate reduction in cases of intracapsular fracture of the neck of the femur, and in fractures about the ankle. Without accurate reduction of subcapital fractures of the neck of the femur, union will not be secured; and without accurate reduc-



## IS ACCURATE REDUCTION OF A FRACTURE NECESSARY?

tion of fractures involving the functions of the ankle-joint, lasting disability, from foot strain, will ensue. Fractures about the knee, also, may give persistent disability if imperfectly reduced; but I must confess that often I have been surprised to learn how little disability may follow a fracture of one or other condyle of the femur, or a supracondylar fracture of the femur, or a fracture of the tibia into the knee-joint, in which reduction has not been anatomically perfect.

It seems to me, then, that the whole matter may be summed up somewhat as follows:

A. In fractures of the shafts of the long bones, it is sufficient to secure: (1) bony union; (2) without axial distortion; and (3) without appreciable shortening. The limits are much wider in children than in adults; and in adults the limits are wider in the humerus and femur, than in the forearm or in the leg bones. But repeated attempts at reduction may give poorer results than leaving the fragments inaccurately reduced.

B. In joint fractures no reasonable effort should be spared to secure anatomical reposition. Even in children joint fractures, if unreduced, may cause lasting disability from axial distortion or limitation of joint movement. The exceptions to this rule are not numerous enough to break it.

C. In all cases the condition of the soft parts is too often overlooked, and proper treatment neglected. The aim of treatment in any case of fracture is restoration of perfect function; and this is only in part dependent upon the form of the bone.

## NON-UNION AFTER FRACTURE

BY KELLOGG SPEED, M.D.

OF CHICAGO, ILL.

AS RÖNTGENOLOGIC study advances and enables us to penetrate more and more into clinical union after fracture, the more difficult it becomes to separate the instances of delayed union from non-union. Delayed union clinically despaired of, illy treated, used, not immobilized, probably leads to absorption of the slight effort made at the fracture site and final non-union. One can no longer say that non-union may exist solely when there is no attempt at repair. Just as true a non-union may be found in the pathology exposed at an operation when there is considerable bulbous callus as when the bone ends are buried in muscle or soft tissues and give no evidence whatsoever of callus. A more specific nomenclature for, or clinicopathologic division into types of non-union must be devised.

Clear cut, rounded fragment ends, those usually associated with pseudarthrosis, are an end stage. Callus may have been present at some stage of the healing attempt, certainly some newly-formed fibrous tissue was, but no calcium salts were deposited in this tissue to cause ossification or calcification as we understand bone healing. The process might be compared to keloid scar formation which lacks contractile power or cutting off of blood supply to form a normal white scar. Instead the keloid remains as more or less young connective tissue, red, œdematous, possibly easily engorged with blood. Callus may likewise linger in the formative stage pending a proper deposition of calcium salts and a final era of calcification or ossification.

As far as we know the process of repair after fracture consists in:

1. Hæmorrhage which may extend into surrounding muscle, fascia or skin.
2. An organization of this blood clot by an ingrowth of connective tissue around newly-formed blood vessels.
3. Calcium and phosphorus salts are deposited in this connective tissue stroma in the perivascular areas.
4. The blood vessels contract or disappear, the newly-formed calcified tissue assumes trabecular arrangement in the physiological axis of the bone, leading to the formation of new bone.
5. Bony trabeculæ responding to the calls of judicious use form in the lines of the original bone and a new supporting scaffold of bone results.

Among other theories as to the cause of non-union it is believed that there is a change in the hydrogen ion concentration of the blood serum in the vicinity of the fracture which changes the local reaction of the blood serum and apparently has to do with the precipitation of calcium salts. An attempt to determine this point experimentally has been made but so far the difficulties obstructing the collection of unbuffered blood from the fracture site have not been overcome. It is supposed that these calcium salts may come

## NON-UNION AFTER FRACTURE

from two sources—from the circulating blood and from the ends of the fractured bones which undergo demineralization and atrophy.

In a study of the prevention of non-union it seems logical that repeated or numerous attempts at reduction of a fracture interfere with this process of bone union. The tissue destruction and vascular disturbance following repeated rough movements probably lead to the formation of products which change the local chemical reaction in the tissues and interfere with the normal deposition of calcium salts. Likewise the vascular outgrowth is disrupted, disheartened and ended—the fibrous tissue cicatrizes and there is no chance for the laying down of calcium salts in a normal manner. Fibrous union results.

It seems that incontrovertible evidence is offered of the local cause of non-union when non-union occurs in one bone after fracture of both bones of the leg. The fibula usually heals bonily, the tibia fails to unite. However, the study of the blood calcium and phosphorus content based on non-union following osteotomy for bow legs in rickets has attracted much attention and has always seemed possibly to offer an explanation of non-union. In 1924 Petersen (H. A. Petersen, *Bull. Johns Hopkins Hosp.*, vol. xxxv., p. 378, November, 1924) claimed that there existed a definite relationship between the concentration of the inorganic bone-forming elements in the blood serum and the healing of fractures. So closely allied was this relationship considered that it was stated that if the product of the phosphorus and calcium content of the blood serum (milligrams in 100 cubic centimetres) was less than thirty, a fracture would not unite. If the phosphorus calcium product was raised above this figure to a normal level by increased diet, fractured bones would unite. Petersen believed that a constitutional disturbance was present in most patients with non-union after fracture, that the amount of phosphorus in the blood serum was particularly low and that the calcium phosphorus product of these two taken in milligrams per 100 cubic centimetres of blood serum had to be not lower than thirty-five to forty to produce bony union. If the product was equal to thirty or lower bony union would not follow after fracture.

Seventeen cases of ununited fracture in human beings were reported by Petersen. Eleven of these patients showed deficiencies in either the calcium or the phosphorus content of the serum, giving low calcium phosphorus products. Petersen took as a mean the Tisdall and Harris (F. F. Tisdall and R. T. Harris, *Calcium and Phosphorus Metabolism in Patients with Fractures*, *J. A. M. A.*, vol. lxxix, pp. 884-885, 1923), findings of adult's calcium of ten milligrams per 100 cubic centimetres and phosphorus 3.8 per 100 cubic centimetres in the study of calcium and phosphorus in normal healing fractures. In six of Petersen's patients who had non-union the blood findings were normal on this basis. It is the writer's opinion that blood serum calcium and phosphorus vary seasonally, geographically, individually, and with the time after fracture that the blood is drawn. It is also found that the estimations must be made promptly with fresh blood.

Baj (L. Baj, Calcium Content of the Blood during Callus Formation, *Gior. d. Batteriol. and Immunol.*, vol. ii, pp. 94-100, February, 1927) studied the calcium content of the blood in normal individuals and also in those with fractures. In normal young patients the average calcium content of the blood was 9.3 milligrams and in normal adults 7.85 per cent. He found that the calcium content immediately after fracture rose, varying on an average from 8.4 milligrams to 10.2 milligrams reaching its maximum on the eighteenth to the twenty-second day after fracture, then decreasing gradually to normal. The fall to normal average was always delayed, however, until the fractures were clinically healed.

The effect of metabolic products and albuminous bodies on the deposition of calcium salts in osteoid and callus forming tissue was investigated jointly by Schwarz, Eden and Hermann (R. Schwarz, R. Eden, and Hermann, *Chemical Processes in the Healing of Fractures*, *Biochemische Zeitschrift*, vol. cxlix, pp. 100-198, 1924), who found that the calcium content of the healthy human bone and bone from other mammals is about 24 per cent., the phosphorus content about 11 per cent. The atomic ratio of the two elements corresponds therefore to approximately 1 calcium to 0.6 phosphorus. After analysis of the callus they found that the calcium content was 16 per cent. and the phosphorus 2.4 per cent. to 5.4 per cent. giving an atomic proportion of calcium to phosphorus of 1 to 0.2 or 1 to 0.4 at the highest. They concluded from these figures that the primary process of ossification consists of a deposition of calcium upon an organic substance which is followed by a secondary reaction of binding of the phosphoric acid until an atomic proportion of 1 calcium to 0.6 phosphorus is reached, at which point the callus becomes bone.

I have repeated Petersen's work on dogs, inducing a reduction of blood phosphorus by dietary methods and subsequently fracturing the legs of these dogs to study the rate of union compared to a normal control dog obtained if possible from the same litter. The rate of union was studied clinically and röntgenologically, and the work was further amplified by making an histologic examination of three- and six-week specimens after fracture in both reduced and control dogs. From study of these animals, a more detailed report of which will be made elsewhere, the conclusion seems logical that the peripheral blood calcium phosphorus product has little if anything to do with the proper healing of the bones of dogs under strict experimental and dietary control.

In the fracture ward at the Cook County Hospital, the senior fracture resident, Doctor Conley, working with me has performed many blood calcium phosphorus determinations on fracture patients. Routine work of this character was carried out on over 200 patients in all seasons of the year, irrespective of age, type or fracture, and bone or bones involved, previous or subsequent (hospital and home) diet, or the time of day blood was withdrawn. Omitting any detailed description of this work it may be said that immediately—meaning within one hour, as blood was usually drawn for the

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first determination before the patient was undressed and his fracture considered—after fracture the phosphorus blood content is low as far as can be told, not knowing what the mean for the individual was before his admission on account of fracture. The calcium content seems to vary but little from what is supposed to be normal blood calcium content for all individuals. The phosphorus content, after fracture, quickly rises, remains elevated—in some instances as high as 5.5 milligrams for three or four days, then gradually falls, depending largely on the length of disability as far as can be determined. Diet has no effect on either the calcium or phosphorus content found in the peripheral blood at this time. Any operative procedure on the human body leads to an immediate rise in blood phosphorus followed by a fall to normal within a few days.

If fracture patients are followed through for a long enough time after showing a relatively low calcium phosphorus product, no matter what diet is used, or whether calcium is administered by mouth or not, there is ultimately a rise of this product to normal. The depression is usually transient and is probably due to muscular inactivity.

The blood phosphorus calcium content was carefully tabulated for ten patients who had non-union after fracture. Some of these patients were under observation over two years. Many samples of blood were examined and most of the patients were operated upon, some successfully, others not. Likewise from a large series of normally healing or average fracture patients whose blood had been studied, ten patients of different ages, types of fracture, and bone involved were chosen to match against the summary obtained in the instances of non-union, using many blood samples over a long period of time. These blood findings were:

Ten patients with non-union after fracture, average blood findings:

|                          |  |
|--------------------------|--|
| Calcium .....            | 10.64 milligrams per 100 cubic centimetres blood serum |
| Phosphorus .....         | 3.53 milligrams per 100 cubic centimetres blood serum  |
| Product of the two ..... | 38.19  |

Ten patients with normally healing fractures gave average blood findings:

|                         |  |
|-------------------------|--|
| Calcium .....           | 10.16 milligrams per 100 cubic centimetres blood serum |
| Phosphorus .....        | 3.87 milligrams per 100 cubic centimetres blood serum  |
| Product of the two..... | 39.26  |

After the experimental work on dogs and an extensive clinical experience and investigation it appears that the blood content of calcium and phosphorus has little to do with the healing of a fracture or the prognosis of non-union after fracture.

Other lines of investigation have attracted men to seek cause of non-union. Recently Oppel, of Leningrad, said it was possible to raise the blood calcium level of an individual by the insertion of a bone graft in the body. Leriche (*Les Problèmes de la Physiologie normale et pathologique de l'Os*) thought that a bone transplant raised the local calcium content and was an aid to bony union. If that were so and a high calcium blood content



had to do with the certainty of healing of fracture, that method of treatment would be an all powerful argument in favor of using an autogenous bone transplant in all patients operated upon for non-union after fracture. This idea has been at least partially exploded by the work of Halperin and Walsh (*Archives of Surgery*, vol. xviii, p. 819, March, 1929), who found in their conclusions in investigating a method of supplying calcium to patient with tetany after thyroidectomy which had involved the parathyroid, that homogenous bone transplants in normal dogs and rabbits failed to raise the blood calcium level. The removal of thyroid and parathyroids may involve other factors in addition to those which have to do with the blood calcium content. These other factors may help induce non-union.

Fontaine reported eight cases of delayed union and pseudo-arthritis which were successfully treated by periarthral sympathectomy. Their attempt was based on the work of Uffreduzzi and Palmax who believed that the healing of a bone took place more rapidly than normal in a limb in which periarthral sympathectomy had been performed. Their eight patients had been treated by both closed and open methods without bony union developing. They claim that in all these cases, even following failure of bone grafts, the performance of periarthral sympathectomy on the affected limb resulted in rapid consolidation of the fracture.

The effect of parathyroidectomy leading to loss of blood calcium may have been expected to bear upon non-union after fracture by producing an alkalosis. Ross' conclusions were that the removal of two parathyroid glands from dogs does not delay healing of fractures, whereas removal of three delays bony union for four or five weeks. The blood calcium level is not diminished by excision of two parathyroids but when three are excised it drops from two to three milligrams per 100 cubic centimetres, and returns to normal as union occurs. (*Relation of the Parathyroids to the Healing of a Fracture as Controlled by the Röntgen-rays*, *Archives of Surgery*, vol. xvi, No. 4, p. 922, April, 1928.) Wells believes that the reason bone is so rarely deposited in veins is that the excess of carbon dioxide, with increased acidity in the venous blood, keeps the calcium in solution. If an alkalosis were present as after pyloric obstruction with vomiting, or after parathyroidectomy, one might obtain local alkalosis and a deposit of blood calcium to heal a fracture. This physiologic theory would not seem to fit into the practical application of the Thomas damming and hammer method where local hyperemia is induced, followed by pounding. The pounding, however, by inducing local change in the tissues, breaking them down and causing acid formation, may lead to a further increase of calcium salts in the surcharged venous blood in the area. The venous blood would hold much calcium, the hammering would cause acid formation and lead to an increase of calcium salts which might cure the non-union, when local precipitation could be secured.

Mild infections occurring after operations upon non-union of fracture may have a similar influence. Clinically, several such instances have been met and it has been felt that the infections lead to an early exuberant callus formation. The local chemical change in the reaction of the tissues may explain this.

This clinical report on non-union after fracture is based on a study of seventy-four patients, seen in the last eight years, most of whom were operated upon, so that material for pathologic and microscopic study was available. There have been no deaths in this series. Three attempts to obtain union have led to failures from infection, one leading to a thigh amputation, one to a leg amputation and the other after a second operative attempt to an amputation of the forearm. In one instance a man suffering from non-union of both humerus and tibia responded by a good bony union in the

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humerus after operation which involved the use of an intramedullary bone splint, but had a tedious convalescence from non-union of the tibia at a second operation in which no bone transplant was placed.

—The probability that local cause leads to non-union seems incontrovertible. To prevent non-union the following suggestions are offered:

Make reduction after fracture as soon and as complete as possible; control by X-ray examination.

Try to eliminate infolded soft parts between fragments by palpation at the time of reduction; the feel of bony surface rubbing on itself is gratifying.

If manipulation and splinting or skin traction fail to give satisfactory reduction, do not hesitate to employ skeletal traction or open operation *early*.

Adopt a sufficiently long period of efficient immobilization for the individual, the bone and the type of fracture concerned.

Do not yield to surgical impatience and adopt methods of treatment which may lead to disaster instead of help.

Do not permit too early or injudicious weight bearing before the bone has hardened or been thoroughly reconstructed.

—Treat the fracture, not an X-ray film.

The treatment of an accepted instance of non-union after fracture may be non-operative or operative. Non-operative treatment is usually prolonged and may be uncertain in its results; however, it may be the wisest course to pursue on account of the patient's general condition, his mentality or because of medicolegal complications. Also the situation, training, and surroundings of the surgeon himself are of considerable importance. Non-operative treatment contemplates first an effort to put the fracture back into the line of original treatment which generally means a plaster-of-Paris dressing. This may bring finally a happy result especially if in the original treatment too early weight bearing or use or improper attempts at immobilization have been used. An efficient plaster dressing or a proper splint may lead to bony union, save the risk, time, and expense of operation with its necessary hospitalization.

Local irritation at the fracture site is also valuable. This may be obtained by guarded use of the part in some sort of splint or support so that irritation may be developed locally in the long axis of the bone, not in the lateral axis which might cause increasing angulation and deformity from contra-axial strain. In leg fractures ambulatory splints and Delbet's splints are helpful.

Massage and local hyperemia are also often required. Dry and moist heat may be used; electric heat has become very popular but is far from being a cure-all. Along with this method of treatment may be put Bier's hyperemia and the Thomas damming and hammer method. Light application by means of a Quartz light up to fifteen minutes daily has some effect on the patient as a whole, and the exposure to light need not involve the fracture field directly. If the patient is septic or marasmic Quartz light is certainly of value. Cod-liver oil, high protein diet, vegetables, milk or buttermilk and phos-

phorus in 1/100 grain doses or even irradiated ergosterol should be used as general tonics and in an effort to supply the blood with all its usual requirements of bone-forming material.

An hypodermic or intra-osseous injection of irritants at the site of non-union is still used as a non-operative method to bring about a cure. Such materials as the patient's own blood, tincture of iodine, bone-marrow extracts, phosphates and emulsion in oil of dried bone are employed. These may promote local bone-forming reaction and lead to union but must all be accompanied by proper periods of immobilization, and supervised splinting.

If these non-operative methods fail and operation is resorted to, the whole scheme of treatment should be reduced to the simplest terms. The equation required to get bony union in physiologic simplicity requires freshened bone ends, recent blood clot and a *reasonable* approximation and fixation of the main fragments. Too rigid, too extensive or exaggerated methods of internal splints are not often required.

Minor operative procedures may bring about bony union. The most useful is cross drilling through the stubborn fragment ends. This can be done through a small incision with local anæsthesia. Multiple cross drill paths are made from one fragment to the other across the area of non-union. Fresh blood is thus carried into and across the field of non-union, new paths through the old callus or fibrous tissue are opened, along which calcification may develop and serviceable union may follow.

Major operations carry certain prerequisites common to all procedures which involve the opening of bony surfaces. A well-planned operation with a careful asepsis is necessary. All interlying fibrous tissue between the major bone fragments must be removed to expose fresh, bleeding, bone surface, to open in some instances the bonily plugged medullary canal of long bone. This exposure must be followed by a coaptation of these bone surfaces if possible. Rarely the loss of bone substance must be bridged by an autogenous bone transplant.

If the skin or soft part surface over the non-union is scarred or recently inflamed, one must wait for all inflammatory evidence to subside or must remove scar tissue and substitute in its place pedicled or transplanted fresh skin flaps. In doubtful instances where later infection is even remotely suspected, and infection may lie dormant in scars for years, heavy massage and use of the part may light up the bacterial growth and cause a recurrence of infection. It is better to do this before operation than to have the operative trauma cause the disaster.

The satisfactory types of operative procedure are:

Simple replacement of the prepared bone surfaces followed by coaptation, by step operations or the use of light absorbable sutures, such as catgut. Kangaroo tendon is too difficult to absorb and may lead to infection. A companion bone as in leg or forearm may have to be shortened to permit coaptation. No attempt is made to do any definite internal fixation of the bone,

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except by interlocking of fragments by position. Immobilization is furnished by a proper external splint after the wound is closed.

Internal splint fixation is also a proper method. For this purpose the bone surfaces are prepared as required in all operations for non-union. The internal splint may be metal, ivory, or bone. It is by far the best to use the patient's own bone. The method of application of the graft may be: (a) Intramedullary graft; (b) sliding, inlay or onlay graft; (c) osteoperiosteal grafts and bone hash.

In spite of criticism and claims of some surgeons that intramedullary bone grafts are not physiologic they possess certain advantages. They are easily and quickly inserted; they give a certain amount of internal fixation. They should be quite long and should not plug tightly the intramedullary canal. They seldom lead to infection or post-operative complication, except perhaps some delay in the full development of endosteal callus which must wait on their absorption.

Sliding, inlay or onlay grafts should be generous in size or really massive. The graft should be cut at least three times as long as the length of the loss of bone substance to be bridged on the poor quality bone with which it will be in contact. If the graft is cut slightly longer than the trough in which it is to lie it can be wedged in by undercutting the cortex at each end of the trough so that it holds firmly, requiring no other fixation. The simplest possible means of fixation should be employed. Heavy sutures of Kangaroo tendon are not required; bone peg screws of autogenous bone are excellent but require a prolonged time of operation and much handling of tissue. Wedging the graft into a carefully measured and cut channel for its reception is enough fixation. In cutting the transplant it is best to use a clean saw different from the one used to open the trough.

Osteoperiosteal grafts and bone hash, made from finely cut up pieces of sterile bone fragments, can be packed in or around approximated bone ends or be used as an adjuvant to other grafts of bone. In the fear of chance of failure, when bony union has been long delayed and other factors are against success, their use is possibly to be encouraged. Bone hash often fills in an hiatus left after freshening bone ends and saves the necessity for resection and shortening of a companion bone as fibula or ulna.

All open operations for non-union after fracture require careful, solid, prolonged external splinting. Plaster-of-Paris is the very best material to use. The splint must be extensive and solidly built to withstand prolonged use because after such an open operation the period of immobilization of the parts is to be from two to four times as long as that required for immobilization after the average fracture involving identical parts. Even slight too early motion after a well-planned and executed operative treatment for non-union may mitigate against a successful result.

The percentage of cures after carefully planned and executed operations for non-union constantly rises. Some operations fail probably because the bone has been ununited too long; its ends are too sclerosed; it must be cut

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back too far to bring any fresh bony tissue into view. The intrinsic osteogenetic power of the bone may be lost, probably on account of prolonged atrophy from disuse or deficient blood supply. Naturally the longer the gap which the surgeon attempts to bridge in an old, ununited fracture, the greater the chance of failure.

Bone transplants and internal splints are really not required in every case; in fact I am omitting them altogether where it is possible to obtain any end-to-end contact between freshened fragments. They are necessary to bridge distance, to lend security after the replacement of fragments or, as in the radius, to prevent rotation and angulation of major fragments until union follows.



## THE IMMEDIATE TREATMENT OF OPEN FRACTURES

WITH SPECIAL REFERENCE TO FRACTURES OF THE TIBIA  
AND THE EVALUATION OF PLATING

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THERE is scarcely any need to emphasize that treatment of open fractures must be immediate; any other belief has so long been incompatible with good surgical judgment and rational practice that it may be considered axiomatic and beyond controversy. But of what this immediate treatment should consist is properly a matter for detailed consideration.

The object of the treatment is to prevent infection of the open wound, and to obtain and maintain reduction of the fracture; this resolves itself into: proper care of the skin about the wound, treatment of the wound, and reposition and maintenance of reposition of the fracture.

It should be emphasized that first-aid treatment must not only "splint them where they lie," but should control hæmorrhage by tourniquet, if simple pressure will not suffice.\* The skin about the wound *may* be painted with iodine against further contamination, but the wound itself should simply be protected by a sterile dressing. Under no circumstances should manipulation of the fracture be attempted and above all, no bone protruding through the skin should be replaced until in the hands of the operating surgeon after proper antiseptic preparation and in safe aseptic surroundings.

In the receiving ward or admission room if hæmorrhage is found to be under control the general condition of the patient should receive first consideration. Shock should be combated by the usual methods of heat, administering of fluids, hypodermoclysis or intravenous saline and glucose, and transfusion, if loss of blood has been a factor. Morphine is especially valuable to minimize the pain or discomfort of adjusting splints, or of a gentle preliminary examination; stimulants are of doubtful value. Tetanus antitoxin, 1500 units, after an intradermal test for sensitization, is administered.

Examination of the fracture area may then be made. Simple inspection will suffice in the majority of cases but should be supplemented by tests for nerve injury. Splints may be readjusted or changed when indicated. Extensive circular crush with mangling of the soft tissues and laceration of the main blood vessels will be indications for primary amputation.

If, and when, the patient's general condition is satisfactory, a radiograph is taken † and he should be transported to the operating room for the care of the fracture and its wound. Only if the receiving ward is manned

\* A tourniquet should be loosened every four hours if it is required for any length of time.

† A radiograph is highly desirable but no delay in immediate treatment to obtain it should be countenanced.

and equipped to afford teamwork and aseptic surroundings similar to an operating room is it justifiable to use it in the treatment of an open fracture. A general anaesthetic should be administered and the procedure should consist of: (1) Treatment of the skin; (2) Treatment of the wound; (3) Treatment of the Fracture.

1. *Treatment of the Skin.*—While cleansing of the skin is undertaken, the wound should be carefully protected by sterile gauze, and the part is shaved. Soap and water may be used but must be followed by copious application of alcohol and ether or benzine, if alcoholic antiseptics are to be used. With alcohol and ether or turpentine excellent cleansing is obtained, and shaving can be done after wetting the hair with alcohol. Personally, I prefer this method to soap and water. Iodine skin disinfection follows, or alcoholic solutions of picric acid 5 per cent. or mercurochrome 2 per cent. may be used.

The wound margins are then carefully sponged with hychlorite 1 to 6, or accurate Dakin's solution, and the wound is draped. Any protruding bone is also thoroughly anointed with pure hychlorite or swabbed with Dakin's strength hychlorite. Dichloramin T 20 per cent. has also been used.

2. *Treatment of the Wound.*—If the wound is small and involves only the skin, it may be thoroughly cleansed with Dakin's solution and sutured and the fracture treated as a closed fracture. If the wound is small and there is evidence of muscle injury or deep soft tissue involvement, the best surgical judgment will be needed to determine the proper treatment. These wounds may be caused either by a sharp spicule or fragment of bone lacerating the skin from within, or by a puncture of the skin from without. Obviously the wound from without promises the more serious consequences by direct implantation of skin, clothing, or soil bacteria. Often the history of the injury will cast the spotlight from which the source of the trauma may be decided. A small laceration caused by the fracture margins, of which the penetration has been slight if any, may be thoroughly cleansed, preferably with Hychlorite-Dakin's, and allowed to close, or if oozing is free, a light packing of hychlorite gauze may be used and the fracture treated as a closed fracture. If an external object has made the wound, or if any doubt exists as to its etiology, or if there is any suspicion of deep contamination, no matter what the cause, the skin wound should be freely enlarged, the extent of the soft tissue injury carefully ascertained and the entire wound thoroughly and meticulously cleansed with Dakin's solution, débrided if necessary, and sutured tight or with a small rubber tissue drain.

With large and obviously contaminated wounds with extensive muscle involvement the cleansing and sponging out of any foreign material and débris must be complete and thorough. Hychlorite-Dakin's should be used and care taken to reach every crevice of the wound. Thorough débridement should follow, but not the extensive débridement of gunshot or shell wounds, usually the snipping away of non-viable muscle fragments is sufficient. After a further flooding of the wound with hychlorite it may be primarily sutured

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either tight or with a corner drain, or packed wide open with hychlorite gauze and Carrel's tubes inserted. The procedure must be taken at the best judgment of the operator. An extensive muscle wound with foreign material ground into it, where a satisfactory débridement has not or cannot be performed should be prepared for Carrell-Dakin treatment and not closed.

Where soil infection of muscles is probable, open treatment is best. ✓ Sherman's <sup>7</sup> practice, however, is to use Carrel-Dakinization as a routine for the majority of these extensive fractures. Swett <sup>8</sup> has recently argued for closure of the wound whenever possible because of the likelihood of infection from frequent dressings of an open wound. He believes infections in open fractures have been fewer since routine closure without tight sutures has been used.

3. *Treatment of the Fracture.*—The skin and wound having received adequate attention, reposition of the bony fragments should follow. If bone protrudes through the skin it requires careful cleansing before the wound is enlarged to permit reduction. If bone protrudes or is exposed in a large wound it should be cleansed as any other part of the wound. If the seat of fracture is away from the wound, after treatment of the wound the fracture may be treated as any closed fracture. When, however, the bone is exposed in the wound it should be reduced by manipulation under direct vision.

Maintenance of reduction will vary with the type of fracture and the individual operator. A transverse fracture in which there may be sufficient serration of the bone ends to hold the fragments together after reposition may be immobilized in moulded plaster splints or a plaster case. However, some form of traction and suspension lends itself best to the treatment of open fracture, especially in the femur and humerus and in spiral and comminuted fractures and those that require frequent dressings. In comminuted fractures, only the completely loose and free bits should be removed. Usually the fragments can be placed in alignment, and notably in the femur and the tibia skeletal traction should be used to maintain the position.

The use of internal fixation in open fractures may still be considered debatable ground. In our clinic there has been no hesitation in plating fractures of the tibia and radius and ulna immediately if oblique or when comminution is slight and there seems little likelihood of proper apposition being maintained without fixation. In extensive comminution, however, suspension traction treatment is to be preferred.

A study of our last sixty consecutive open fractures showed a distribution as follows:

|                        |                       |  |
|------------------------|-----------------------|--|
| Humerus .....          | 0                     |  |
| Radius and ulna .....  | 14                    |  |
| Femur .....            | 8                     |  |
| Tibia and Fibula ..... | 38 (63 1/3 per cent.) | <div style="display: inline-block; vertical-align: middle;"> <div style="font-size: 2em; vertical-align: middle; margin-right: 5px;">}</div> <div> Upper third, 6<br/> Middle third, 17<br/> Lower third, 15 </div> </div> |

Two were admitted with infection. Six (10 per cent.) developed infection—five quite mild, but one a gas gangrene from reduction of protruding bone before admission to the hospital. There were three deaths—two from

pulmonary embolism in the third week, and one in twenty-four hours from the shock of multiple fractures.

The preponderance of fractures of the tibia and fibula is immediately striking ( $63\frac{1}{3}$  per cent.). This was noted also in a previous report from our clinic (Estes, Sr.<sup>4</sup>), and has been remarked by Swett<sup>8</sup>—61.5 per cent. in his series. Having been informed by Dr. L. A. Shoudy, of the Bethlehem Steel Company, that open fractures of the tibia were particularly a protracted problem in his follow-up dispensary treatment and realizing that it has been customary to plate many of these fractures, a detailed study has been undertaken to determine the relation of plating, if any, to end results:

*Fractures of the Tibia (38)*

|                                    |                 |    |
|------------------------------------|-----------------|----|
| Delayed Union, 18 (47.4 per cent.) | { Upper third,  | 1  |
|                                    | { Middle third, | 12 |
|                                    | { Lower third,  | 5  |

Twelve were plated.

One had slight infection.

Of these one had Wassermann ++. No active lues. One had low calcium (9.0) and Phosphorus (2.5). Age was not a factor; none of the cases was over fifty years.

*Comminuted Fractures (14)*

|                    |              |
|--------------------|--------------|
| Normal Union.....  | 5 (4 plated) |
| Delayed Union..... | 9 (7 plated) |

Three plated immediately. Delayed union in all.

Bone fistulas, 3

Non-union, 0

Union is notoriously indolent in open fractures of the tibia and has been observed with all forms of treatment, even with skeletal traction, but if plating delays union it does not seem likely that plating *per se* but the increased trauma incident to the application of the plate may be the factor. It must be remembered also that those fractures selected for plating are usually the most difficult to handle and those attended by more severe injury.

Due to the kindness of Doctor Shoudy another group of industrial fractures with complete records has been personally examined to estimate the final results of plating:

*Fractures of Tibia, Industrial (31)*

|            | No. | Good Anatomical Position | Same Job            | Non-union | Bone fistulas | Average time out of work |
|------------|-----|--------------------------|---------------------|-----------|---------------|--------------------------|
| Plated     | 19  | 14 (73.7 per cent.)      | 17 (90 per cent.)   | 0         | 10            | 9½ months                |
| Not plated | 12  | 8 (66.6 per cent.)       | 10 (83.3 per cent.) | 1         | 1             | 7 months                 |
|            | 31  | 22                       | 27 (87 per cent.)   |           |               |                          |

Though this is a comparatively small group of fractures it represents the worst and especially difficult cases, most of them being open comminuted fractures which had been treated in St. Luke's Hospital previously. It will be noted that 90 per cent. of the plated fractures were able to return to the same job, and that anatomical position was obtained in 73.7 per cent. of

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these—a higher per cent. than those that were not plated. The great preponderance of bone fistulas, however, in the plated fractures is obvious, also that the average time out of work is prolonged, but there was no non-union in the plated group. What seemed particularly striking was the fact that in these protracted cases, which required long periods for treatment, 90 per cent. of those plated eventually returned to the same job; in other words, their economic use was restored. In some instances they were back on the job and still under treatment for bone fistulas, the longest of which persisted or recurred for two and one-half years, but there was not one that has not been completely healed for a year or more. There were two men over fifty-five years of age that presented an interesting complication; namely, a scar that tended to become eczematous or break down because of associated varicose veins of the leg.

✓ For the past ten years Sherman<sup>6</sup> and Wagner<sup>7</sup> have plated practically all ✓ extensive open fractures of the tibia other than the badly comminuted, immediately following the débridement of the wound, leaving the wound wide open and using the Carrel-Dakin treatment. Infections have been exceedingly few. The plates are removed in five weeks and the wound is allowed to heal by cicatrization. Fractures with small wounds are simply dakinized and if after ten or twelve days they are sterile, plating is performed through a fresh incision. Auvray's<sup>2</sup> practice is very similar to Sherman's.

Eliason<sup>3</sup> states: "In severe cases of compound fracture of the tibia requiring frequent dressings it is desirable to apply a plate even in an infected wound until callus is sufficiently strong to resist displacement incident to movements of the leg during dressings."

Fagge<sup>5</sup> believes: "Primary plating is not generally advisable but cases occasionally occur particularly in the lower third of the tibia in which a reasonable degree of alignment cannot be obtained much less maintained by ordinary splint treatment." He uses immediate traction by Sinclair skate and Thomas splint. If by the time operation and débridement is performed the position is not satisfactory, plating is seriously considered and the wound is left unsutured. Plating, however, is the exceptional rather than the usual treatment.

Ashhurst<sup>1</sup> stresses the importance of securing anatomical reposition of the fragments not only to obtain ultimate good function but to lessen the period of disability. In open fractures of the tibia only one-fourth of the patients will obtain good function unless accurate reduction is secured. The average period of disability is seven months. In comminuted fractures, skeletal traction by the Steinman pin is superior to the Sinclair skate; a steel plate may be used when there are not more than two or three fragments.

Wilson and Cochrane<sup>9</sup> believe that only in rare and exceptional cases of open fractures should metal plates be used, as they act as foreign bodies, are detrimental to wound healing, and various splints maintain reduction and alignment equally well.



CONCLUSIONS

I hold no special brief for plating, but these statistics and this investigation have been made with the sincere attempt to evaluate plating in open fractures of the tibia. I have no sufficient group of fractures treated by skeletal traction to compare with these, but until we have statistics that can show better end results, it seems to me that plating certainly cannot be ignored. However, each operator must establish his own indications and be prepared to meet the open fracture problem by more than one method. It must be emphasized that plating, to obtain the best results, must be done by one fairly versed in its technic.

Open fractures demand immediate treatment and this treatment logically will be: (1) Treatment of the skin; (2) treatment of the wound; (3) treatment of the fracture. Successful results depend not only on *what* is used to accomplish this treatment, but *how* it is used.

BIBLIOGRAPHY

- <sup>1</sup> Ashhurst: Report of the Committee on Fractures of the American Surgical Association, p. 125, 1921.
- <sup>2</sup> Auvray: Bulletin Mem. Society, Nat. De Chir. Paris, vol. iii, p. 828, 1926.
- <sup>3</sup> Eliason: Nelson Loose Leaf Living, Surgery, vol. iii, p. 381.
- <sup>4</sup> Estes, W. L.: International Journal of Medicine and Surgery, November, 1926.
- <sup>5</sup> Fagge: Practitioner, London, vol. cxv, p. 179, 1925.
- <sup>6</sup> Sherman: Nelson Loose Leaf Living, Surgery, vol. iii, p. 409.
- <sup>7</sup> Sherman and Wagner: Personal communication.
- <sup>8</sup> Swett: Boston Medical and Surgical Journal, vol. cxcvii, p. 1257, 1928.
- <sup>9</sup> Wilson and Cochrane: Fractures and Dislocation, p. 57, 1925.

## THE TREATMENT OF RECENT FRACTURES OF THE LONG BONES BY OPERATION

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THE climate of surgical opinion concerning the treatment of fractures is exceedingly foggy. The mists of many poorly founded individual opinions are beclouding the whole subject of treatment. Splendid progress has been made in fracture treatment in recent years, and even greater advances will be evident in the future.

For thousands of years fractures were fixed, the joints above and below immobilized by constricting splints and bandages. The soft parts—skin, muscles, fasciæ, nerves, and vessels—were left to take care of themselves, neglected.

This non-operative treatment is followed traditionally still in certain parts of the country. Out of this rigid, senseless system have gradually developed modern methods of treatment.

Sporadic efforts have improved treatment. Bardenheuer employed traction and countertraction and suspension. Buck also used traction and countertraction. The traction force was applied to the skin of the extremity with only relative efficiency.

Through the monumental work of Pasteur and Lister, the mortality of compound fractures was lowered. Lambotte, of Belgium, accepting Lister's conclusions, conceived the idea of diminishing the crippling due to fractures by a direct operative treatment. He had been at work in his own surgical laboratory some years and first published, in 1907 and again in 1913, a treatise upon the treatment of fractures by operation. Lane studied the effects of fracture on osseous tissue, and in 1893, 1897, and 1898, wrote on the operative treatment and proceeded to apply his theories to the limit.

Lambotte stands, in my opinion, as the originator and father of the idea of approaching fractures directly by operation. As Ashhurst has well stated, Lambotte's treatise on the surgery of fractures gives a concise, clear, comprehensive recital of the operative technic, which up to 1913 was unexcelled.

Isolated instances of operation for fracture occurred abroad and in America before the above date. In general, thirty years will cover the time during which fracture treatment by systematic operation has been developing.

The serious discussion of the operative treatment of fractures really coincides with the present technical perfection of pathological surgery. The aseptic régime, as practiced in general surgery, makes possible the treatment of fractures by operation. Rigid conformity to the established aseptic ritual is essential to success and is postulated in this presentation.

The treatment of recent fractures by operation is a safe treatment. The mortality is low, about as low as is the mortality following any major surgical

procedure. The operative treatment of fractures is safe and stands on the basis of aseptic surgery.

The conception of bone which exists today is more precise and comprehensive than that which has ever been held before. Bone is no longer regarded as a relatively dry, inert, stable form of matter, serving as a passive framework of the body. Bone is a flexible, living, changing tissue, an active organ, intimately associated with vital processes.

The bony skeleton is a protection, a support, a means of locomotion, but it is related to certain physiological processes; it is a reserve of calcium. Bone is the chief organ concerned in the formation of the cellular elements of the blood. Bone tissue is sensitive to all extraneous influences. The reaction of bone to trauma, to fracture, is recognized as a complicated series of events—the process of repair.

This conception of bone emphasizes the importance of gentle, immediate, and, as nearly as possible, exact manipulative reposition of fracture fragments in order that the reparative processes may be least interfered with, to the end that ideal union may be accelerated. The treatment of recent fractures by operation is based on the pathology of repair.

Cowan, in a recent study on the healing of fractures, has called attention anew to the necessity for securing firm contact over as broad a fractured surface as possible so as to permit the reparative process to function at a normal maximum. Under these conditions union will almost always occur. Therefore, from the pathological basis of repair, we feel the urge in treatment to secure firm bony contact. Under certain conditions, this may be obtained by operation more precisely than by other methods. The processes of union are facilitated by accurate apposition.

Bancroft, in a recent study, says: "From a study of the repair of fractures in human subjects, as well as in experimental animals, it is my conviction that the future of the repair of a fracture depends almost entirely on the immediate local treatment that the patient receives and very little upon the systemic metabolism of that individual. That is, if a fracture is immediately treated in a manner which will replace as far as is feasible the fractured ends in suitable apposition and allow for the organization of the clot and the ingrowth of granulation tissue with its accompanying vessels, repair will inevitably follow."

Clinically, this means that if a fracture is so treated that there will be no constriction or obstruction to its blood supply and that there is sufficient immobilization to allow the growth of granulation tissue without its being constantly broken up and interfered with by the movement of the rough fractured ends of bone, repair will proceed in an orderly manner. The processes of union or facilitated by firm reposition and apposition. Every effort must be made to bring about these conditions.

The pathology of repair underlies both the non-operative and the operative treatment of a fracture.

## OPERATIVE TREATMENT OF FRACTURES

We possess today certain methods of treating fractures, tried out and followed in different clinics in this country and abroad. (1) A method of massage and mobilization introduced and furthered by Lucas Championiere, in France; the method now followed and practiced by Mennell, in London. Certain cases with little displacement lend themselves to this form of treatment. It is a time-consuming personal method, but under suitable circumstances remarkably effective. (2) The method of using a general anæsthetic and immediately setting the fractured bones, as practiced by Willis Campbell, of Memphis, Tennessee. The reduced fracture, checked by X-ray, is held in plaster-of-Paris splints. Mobilization is begun early enough to secure, under Campbell's supervision, results in fractures of the long bones comparable with some other methods. (3) The treatment with adhesive plaster skin traction, checked by X-ray, as used by Ashhurst, of Philadelphia. (4) The method of regional and local anæsthesia. This is as yet an experimental method applicable to certain cases and distinctly valuable. (5) The treatment by skeletal traction, as practiced in some form now in most clinics of the world. This is a recognized safe and efficient method of applying traction which at the same time permits movements of the joints contiguous to the fracture; a wonderful addition to fracture treatment. As practiced by Conwell, in Fairfield, Alabama, cases of fracture of the shaft of the femur in adults return to light work in from four and a half to five and a half months, and to heavy work in from six and a half to seven months. In a series of one hundred and ten cases, 80 per cent. of them were treated by skeletal traction and suspension of the limb. Open reduction was done in this series only four times; twice for muscle interposition, and twice because of delayed union. Such in general are the non-operative methods ordinarily available.

(6) Treatment by operation, the direct approach. (a) Simple incision and replacement. This is applicable to a few fractures. LaFerté, of Detroit, has used this method in a large series of cases with little or no sepsis; with admirable functional results; with only an occasional slipping of the fragments after reduction. Plaster-of-Paris is used for fixation after operation.

(b) Simple incision, replacement, reduction maintained by absorbable suture; a method which may exceptionally be successfully used, but too often it permits slipping of fragments post-operatively.

(c) Simple incision and fixation by some form of non-absorbable material, such as plates and screws, as used in the Pittsburgh clinic of O'Neil Sherman. It is interesting that from this clinic I have records of one hundred cases of oblique and transverse fractures of the femur (not compound) in which there was displacement. In many of these cases there was an interposition of soft parts. They were all cases of fractures in healthy adults. Each case was treated by incision and the application of a steel plate held by screws. The patient was kept in bed and prepared for the operation ten days following the accident. He was fitted to a walking caliper at the end of ten weeks; and was walking with the caliper after ten weeks. The caliper was worn from nine to twelve weeks. The patient was bearing weight with support

after five weeks; and he was back at work on an average in six and one-half months. In 95 per cent. of the one hundred cases there was no disability; there was slight disability in flexion of the knee in from 5 to 10 per cent. only. In the one hundred cases, there was one case of secondary hæmorrhage which required the opening of the wound. There was one infection which was controlled. In each case an X-ray plate demonstrated solid union at the time of weight bearing.

This is a record of the employment of operation with non-absorbable material for fixation which, because of the control had over the individual patient, shows what this method can accomplish under such circumstances. It is a splendid demonstration of this method. The work and accomplishments of this clinic are a distinct contribution to the advance of the treatment of fractures.

The success of any of these briefly sketched methods available for treatment of recent fractures of the long bones is dependent in the first and last analysis upon the fact that one person is primarily concerned with the treatment from inception to finish, and that he alone is responsible. The decision upon the method of treatment in a particular case is less a question of the non-operative versus the operative treatment than it is the selection of those cases which are suitable for each form of treatment.

With our present knowledge of the results of ideally conducted non-operative methods and the results of ideally conducted operative methods, it is impossible to state a final opinion of the applicability of one method of treatment to a certain fracture. Our opinions will necessarily vary. Standardized fracture treatment is as undesirable as it is impossible of realization. New knowledge and new methods will continue to cause us to change our attitude toward the treatment of individual fractures.

The operative treatment rests upon bases that are at once solid, sound, and enduring; namely, established asepsis and the pathology of repair.

In every fracture we are confronted with its peculiar individual characteristics; its special problems. A fracture is an injury to a complicated and intelligent mechanism. The will is involved in every fracture; it influences the recovery of function. The recovery of the normal functioning of the whole organism is at stake, not merely the healing of a broken bone.

#### CERTAIN FACTS CONCERNING THE OPERATIVE TREATMENT OF FRACTURES

The operative treatment of a recent fracture necessitates the finest technique in surgery and a suitable equipment.

The treatment of recent fractures in childhood by an open operation is rarely indicated.

The operative treatment requires a careful approach to the fracture. These approaches are undergoing continuous scrutiny in order that trauma may be minimized. Henry, of Dublin, and Thompson, in Texas, have each contributed constructively to this phase of the subject.

It has been held that the use of the operative incision itself in approach-



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ing the site of fracture tends to, and actually hinders, the repair of the fracture. The operative incision properly placed and made by sharp dissection does not appreciably hinder repair.

It has been likewise held that the placing of a plate upon the fragments of a fracture retards the formation of callus. My feeling on this point is that even though callus at the exact site of the plate is sometimes absent, the presence of the plate offers no *material* disadvantage in the ultimate repair of the fracture.

The indication of the use of the open operation in the treatment of a recent fracture is that by the open operation there is obtained an earlier return to a more nearly normal function than by other available treatment. The treatment of recent fractures by open operation is no longer a last resort when other methods fail; it now occupies an established place in surgery; it is in many instances an initial method of choice.

We must always assume, in considering the use of the operative treatment, that in the individual instance:

1. The highest degree of safety will obtain.
2. The surgeon and his assistants are skilled in the treatment.
3. The surgeon possesses ability greater than that legally required.
4. The surgeon has available the necessary instruments and apparatus.
5. The use of the form of anæsthesia suitable to the case will be skilful.
6. The final and exact procedure chosen in the operative treatment of a given case is appropriate.
7. The pre-operative and post-operative care is adequate.
8. By this treatment the involved or contiguous joints are moved as early as possible.

May I enumerate a group of fractures in which it has already been pretty satisfactorily demonstrated that it is unwise to use closed methods and in which treatment by operation is appropriate.

Many fractures into joints with displacement of fragments.

Fracture of the great tuberosity of the humerus.

Fracture of the surgical neck of the humerus with dislocation of the head of the bone.

Displaced condyles of the humerus not held by acute flexion.

Fracture of the olecranon.

Certain elbow fractures in adults.

Certain metacarpal fractures.

Certain carpal fractures.

Certain fractures of the head and neck of the radius.

Fractures of the radius with deflection of the fragments toward the ulnar side.

Irreducible fractures of the shaft of the femur.

A displaced femoral condyle.

Fracture of the patella.

Certain spiral fractures of the bones of the leg.

Certain metatarsal fractures.

Certain fractures of the os calcis.

In the large and important group of fractures of the neck of the femur, we are coming to understand more and more the limitation of the treatment by abduction. It may some day be possible to select, with greater accuracy than today, from this group those cases in which the abduction treatment is not suitable. Treatment by operation may be found satisfactory for certain cases of fracture of the neck of the femur. This whole group of cases here stated will vary from time to time.

It is difficult to state what amount of displacement is consistent with a satisfactory result. It is not primarily the anatomical result we want; it is the best functional result obtainable. The approximation to an anatomical result is desirable because it is recognized that the factor of position is an important one in determining function. We may have a poor anatomical result and good function. That doesn't mean, however, that we should permit poor anatomical alignment in our method of treatment. We must always, I believe, hold out as a goal of our treatment, function as of first importance and permit the other factors entering into the problem to adjust themselves as is most logical.

*Conclusion.*—We have in the operative treatment of fractures a sound, safe, and efficient method. We will choose it primarily in certain cases because it yields the best results. *We will honestly try in all doubtful cases the non-operative traction method first.* We will find that the honest use of skeletal traction will diminish the number of cases requiring primary operation. In adults, ten to fourteen days may be employed in using the non-operative method before resorting to operation.

If one is master of the general principles and technical details of both the non-operative and the operative treatment of fractures, is informed as to the results of such treatment, has a complete knowledge of the proper use of massage and active movement, and can secure the patient's complete coöperation, one's vision of the surgical treatment applicable to a given case of fracture of bone will be so broad, one's selection of the treatment will be so wise, and one's execution of the treatment chosen will be such that the result both functionally and anatomically will be the best obtainable for that particular individual under the existing conditions.

## DISASTERS FOLLOWING OPERATIVE TREATMENT OF FRACTURES

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In adopting the operative treatment of a fracture the surgeon should visualize potential disasters in order that their danger may be minimized. In calling attention to certain complications and difficulties it is usually possible to collect statistical data which will present a picture of mathematical probabilities. Unfortunately, such a portrayal cannot be offered in this instance. Figures are available from a few men whose experience has been fairly extensive. But most of the disasters do not occur in such hands, but rather do they visit those who do not appreciate the need for careful attention to detail nor the importance of publishing unfortunate results. One does not have to operate on many fractures to become personally aware of the difficulties and dangers. Nor does one have to see much of the work of others to realize that his own experience is not very exceptional. Accidents occur in the best regulated families but they occur much more frequently where regulations are slipshod and careless.

*Infection* is the commonest disaster associated with the open method. The result may vary between a little delay in healing of the wound to severe sepsis and amputation or death. One of the main factors in combating infection is the ability of the tissues to resist the invading organism. This depends very largely on the circulation in the tissue involved, not only on the normal capacity of the vessels but on their ability in emergencies to carry to and from the affected area much larger amounts of blood. Fractured bones are as badly equipped as any tissue in the body to meet this need. First the blood supply of bone is comparatively scanty. The vessels of the periosteum and, to a far greater extent, those within the bone are in dense resistant tissue. Many of the vessels are torn across by the fracture and the periosteal stripping that occurs with any displacement of fragments. As in warfare the success of any engagement with the enemy depends largely on the means of communication. Only a certain number of men or trucks can pass over a road of a certain width in a certain time. The narrower and the fewer these roads are the greater will be the embarrassment to the army when an emergency arises. This periosteal stripping is usually greatly increased by the manipulations of reduction. The wonder then is not that bone is so often infected when exposed, but rather that it ever escapes. When the bone does become infected the area may be limited to one surface of the bone, so that the process of repair may proceed at almost normal rate in the rest of the bone and strong union result. On the other hand, the death of tissue may involve the whole diameter of one or both fragments, resulting in most distressing loss of substance.

If it is realized that bone, and especially traumatized bone, is far more susceptible to infection than other tissues, the meticulous precautions necessary in the operative treatment of fractures will be undertaken more conscientiously. The so-called "Lane Technic" is neither faddish nor foolish, but distinctly worth while. It should be broken only when its strict observance unnecessarily prevents or delays the successful accomplishment of the operation. Longer and more thorough skin preparation is necessary, especially when splints and bandages have allowed the outer layers to accumulate. Nothing should enter the wound that has been touched even by a gloved hand. The tissues should be handled gently and the periosteum left in contact with the bone wherever possible.

*Hæmorrhage.*—Fatal or severe hæmorrhage is more often due to faulty approach than to imperfect control. Most of the long bones can be reached by "dry" routes. Some men do not take the trouble to work these out. I have seen a fatal hæmorrhage from a femur where the external approach was used. I have seen several femurs operated on by the anterior approach where no ligatures were required. The site of fracture should be exposed by a route which will result in the least injury to overlying soft parts. When a large vessel has been injured by the original trauma alarming hæmorrhage may occur as the field is exposed. Such a disaster need not weigh quite as heavily on the conscience of the operator as one that results from his own ignorance or carelessness.

*Vascular Interference.*—Delayed or non-union may result from operative interference with the blood supply. Careless approach and wounding of important vessels may seriously impair the circulation. Wholesale stripping of periosteum undoubtedly delays union. The most serious effect of vascular interference is its predisposition to infection.

*Faulty Material.*—Reliable material is essential to successful treatment of fractures no matter what the method used, but this is especially true in the operative method. It is bad enough to have plaster crumble or crack or to have a traction cord break but they can be replaced rather easily. When a post-operative film shows that a plate has broken and the wound must be reopened it is indeed a tragedy. Today there is apparently a very serious situation in this country. During or soon after the war there was a sudden demand for plates and screws and a large supply was made up of inferior material and workmanship. Two accidents recently have occurred to us due to our failure to carefully examine a new shipment of plates and screws. One plate bent and a second one broke, the latter while the femur was encased in plaster. A later checking over of our supply showed the large majority of the plates faulty and almost all the screws carelessly finished. It was shown long ago that wood screws will only hold a very short time and that self-tapping machine screws must be used. When the grooves are not well cut or the heads off centre or the notches improperly placed, poor workmanship will result. One always hesitates to use plates and screws but unless one can be sure of their holding the risk becomes too great and disaster too

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likely. It is hoped that this warning will lead to a careful inspection and return of all material of this type. The matter has already been taken up with the manufacturers but if the dealers can receive from all over the country these faulty goods the remedy will be more promptly found. Other forms of material, sutures, whether silk or fascia or chromic or tendon, may prove to be weaker than expected and result in distressing situations.

*Faulty Technic.*—Many of the disasters of operative treatment can be directly traced to poor technic. Careless examination of patient and X-ray evidence, unsound appreciation of what can and what cannot be accomplished, faulty approach, failure to provide proper tools, clumsy procedure, rough handling of tissues, careless immobilization and after-care are far more often to blame than the method itself.

*Delayed Decision.*—Only too often is the operative method used as a last resort. Other methods are tried and only when the opportunity has gone forever is the attempt made by the open method to accomplish something which might have been comparatively simple and safe in the early stages of repair. Such instances of omission or delay are just as much disasters as are those where the operative method is improperly used.

*Faulty Judgment.*—The disasters due to errors of judgment are often humiliating; when we leave a fracture we have successfully reduced without proper fixation, only to have the displacement recur; when we misread an X-ray to find the operation unnecessary; when we believe we can obtain a reduction and find we have only made it worse; when we concentrate on the outstanding lesion to discover later that we have overlooked an associated injury; when we attempt to repair a deformity too soon after an infected fracture. These are all disasters but often forgivable.

### SUMMARY

The disasters which may follow the operative treatment of fractures should be known and faced. These are due to:

1. Infection. Bone is more susceptible to infection than any other tissue. Unusual precautions must therefore be taken.
2. Hæmorrhage. More often due to faulty approach than imperfect control.
3. Vascular interference.
4. Faulty material.
5. Faulty technic.
6. Delayed decision.
7. Faulty judgment.

DISCUSSION: DR. WILLIAM L. ESTES, of Bethlehem, Penna., said that the keynote for the treatment of fractures was struck by the Fellow who spoke of faulty methods and of the chemical possibilities of the blood and organs generally, and who finally concluded that after all, the proper thing was the conservation of the blood supply and the proper adjustment of the fragments.



## DISCUSSION

The proper blood supply not only depends upon the direct injury to the tissues and blood vessels, to be prevented by securing fixity of the broken bone by some object from without perhaps, but also upon the possibility, and frequently the existence of *tension* in the soft tissues, from hæmorrhage for instance, on account of lacerated tissue and displaced muscles. In order to prevent this the surgeon ought sedulously to avoid tension, and should prevent the occurrence of tension. The speaker then showed a series of lantern slides illustrating various points in his own methods of dealing with complicated fractures.

DR. JOHN B. WALKER, of New York City, spoke upon the late results of fractures of the long bones of the World War cases. The sick and wounded records of the office of the Surgeon General of the Army and the later records of the Veterans' Bureau furnished an unusual opportunity to secure important data concerning injuries, especially fractures. Battle fractures ranked for death first below tuberculosis which was number four among diseases, influenza, lobar pneumonia, bronchopneumonia and tuberculosis—but fractures were relatively much more important as the cause of loss of time and permanent disability.

The most serious cases were the gunshot fractures of the femur and it was in this class of cases that the greatest improvement in the treatment of fractures was developed during the war.

During the Civil War there were 6549 fractures of the femur with 3434 deaths, a fatality of 52 per cent.; during the World War 3850 fractures of the femur with 971 deaths, a fatality of 2 per cent. Of the deaths following fracture of the femur 43 per cent. occurred within the first three days and 55 per cent. within the first seven days. In the Civil War there were 7888 cases of fractures of the humerus with 1639 deaths, a fatality of 21 per cent.; during the World War 4069 cases with 414 deaths, a fatality of 10 per cent.

There were 147,651 gunshot injuries, 25,272 or 17 per cent. were fractures. There were 12,192 deaths and of these 2751 or 23 per cent. were due to fractures, and of these deaths 47 per cent. occurred within the first three days and 60 per cent. within the first seven days. The loss of time due to fractures was 35 per cent. There were discharged for disability 25,187, of which 11,740 or 47 per cent. were due to fractures.

*Amputations.*—Four thousand one hundred seventy-eight amputations were performed; of the femur, 1817; tibia and fibula, 1190; humerus, 727; radius and ulna, 444. Seventy-three per cent. were performed within the first fifteen days. No one soldier lost both arms and both legs; only one soldier lost both legs and one arm and not one lost both arms and one leg. Twenty-two lost both legs at the thigh, forty both legs below the knee and seven lost both forearms below the elbow.

*The late results* of some of these cases after six years are as follows: Of the total cases only 16 per cent. had a disability of less than 10 per cent.; 44 per cent. had a disability of between 10 and 29 per cent.; 16 per cent. had a disability between 30 and 49 per cent.; 15 per cent. had a disability between

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50 and 79 per cent.; 6 per cent. had a disability between 80 and 99 per cent.; 3 per cent. had a disability of 100 per cent.

*Femurs.*—Fifty-one per cent. of the femurs required more than five years to reach their stationary level of improvement, a level reasonably certain to continue through life. At this time only 5 per cent. had a disability of less than 10 per cent.; 47 per cent. were rated between 10 and 49 per cent. disabled and 48 per cent. were rated between a 50 and a 100 per cent. disability.

*Tibia and Fibula.*—Forty-nine per cent. required more than five years to reach their stationary level; at that time 17 per cent. had a disability less than 10 per cent.; 72 per cent. were rated between 10 and 49 per cent. and 11 per cent. were between 50 and 100 per cent.

*Humerus.*—Fifty-five per cent. required more than five years to reach their stationary level; at that time 10 per cent. had a disability less than 10 per cent.; 57 per cent. were rated between 10 and 49 per cent. and 33 per cent. were between 50 and 100 per cent.

*Radius and Ulna.*—Forty-nine per cent. required more than five years to reach their stationary level; at that time 17 per cent. had a disability less than 10 per cent.; 55 per cent. were rated between 10 and 49 per cent. and 28 per cent. were between 50 and 100 per cent.

These ratings seem unusually high and the duration of the disability much prolonged. However, 80 per cent. were compound and due to severe battle injuries; the fractures became septic—osteomyelitis developed in 74 per cent. with much destruction of tissue, resulting in lasting deformity with much impairment of function. Also, an associated nerve injury in 14 per cent. of the fracture cases was responsible for increasing the prolonged duration of disability.

DR. DALLAS B. PHEMISTER, of Chicago, Ill., spoke about the influence of necrosis of the head of the femur upon union in cases of intracapsular fracture of the neck of the femur, and the ultimate functional results.

The head becomes completely necrotic in many cases of intracapsular fracture of the neck of the femur. When this happens non-union usually follows. There may be revascularization and connective tissue invasion of the dead head following hypertrophy of the vessels of the round ligament. In that case it may be gradually absorbed and partly replaced by new bone. This comes about slowly and the head casts a heavier shadow in the X-ray than the surrounding living bone which undergoes atrophy of disuse. In case of impaction there may be non-union between the necrotic head and the distal fragment and at first the functional result may be fairly satisfactory. However, the head eventually goes to pieces. The weight-bearing portion gradually breaks down as a result of walking and there is more or less absorption of the necrotic portion by the invading connective tissue, so that eventually a markedly deformed and poorly functioning head is the result.

In other cases of intracapsular fracture, the head fragment receives sufficient nutrition to remain alive. In some cases the fracture unites and a good functional result is obtained. In other cases the fracture remains

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ununited and the head undergoes atrophy of disuse along with the other bones of the region.

DR. JAMES MORLEY HITZROT, of New York City, said that the great difficulty in teaching fractures to the average student is to give him some perspective from which to work. In looking at it from a great many different angles the speaker had evolved these four classes:

1. *Fractures which will give a good result with any ordinary treatment.* In that group would be included the fractures without displacement, fractures with slight degrees of displacement easily corrected by simple manipulation, many of the fractures in children especially the green stick fractures, and some of the fractures which may be treated by the simpler forms of traction. Here also may be included many fractures of the clavicle, ribs and scapula.

2. *Fractures that require special treatment, skilfully applied, for a good result.* This includes perhaps the largest variety of bone injuries, such as for example the fractures about the wrist-joint, the fractures about the ankle-joint, fractures of the patella and olecranon, fractures of the long bones with varying displacements, and some of the compound fractures.

3. *Fractures that may result badly with any form of treatment, but which require special treatment for the best possible results.* Nos. 2 and 3 overlap necessarily. There may be a considerable difference of opinion as to where a fracture might be placed. As a rule in Group 3 are included the more serious types that one would find under Group 2. These would include the fractures which involve the joints, fractures of the neck of the femur, the pelvis, many of the compound fractures and certain of the fractures of the vertebra. In this group he would also include fractures of the tarsal bones such as the os calcis, and of the carpal bones such as the scaphoid. Many of the skull fractures may well be placed here.

4. *Fractures which will give an indifferent or poor result no matter how skilful the treatment.*

Students should be taught the emergency treatment. All medical students should receive sufficient instruction and experience along practical lines to learn to recognize that they are dealing with a fracture, in order to avoid additional injury by injudicious manipulation. They should be taught the practical methods of splinting the injured limb with special attention to the use of the Thomas splint. They should also be taught that each fracture is a surgical emergency which should be transported carefully and treated promptly, and if possible an X-ray picture should be made as it is of great value in determining the character of the bone injury. That does not mean that an X-ray is necessary to determine there is a fracture. If an X-ray can be made immediately it is of great help in determining the character of the bone injury.

Then, by the use of one of the above four groups, or some similar grouping they should be taught the simpler methods applicable for the treatment of the first group. Emphasis should be laid upon the necessity for a prompt consultation, or of prompt splinting and transportation of the other three

## TREATMENT OF FRACTURES

groups to a place suitable for their prompt treatment. To him this means a hospital wherever and whenever it is possible.

All of the above things mentioned are functions of the ordinary man, things which he can learn with very little experience and which put no undue strain on his ability, and do not require him to learn all the complicated methods which are of necessity learned in a clinic where they are used. It isn't so much the method as it is the man behind the method that determines the outcome.

One of the factors surgery is facing now is the fact that there is a great deal of unskilled treatment applied in the use of methods which in the hands of the proper men, skilfully applied, are successful. He thinks teachers will have to revise their teaching to teach the men how to do the simple things and to call for help and call early and often when they get into the more serious matters.

DR. EMMET RIXFORD, of San Francisco, Cal., said that it is a fitting time to realize that there are many methods of treating fractures, and that each one of them has its advantages when properly applied.

It is a good thing that there are different ways of doing things. Multiple methods simply add to the elasticity of one's armamentarium, for methods are really instruments.

One should not be a faddist and try to treat a large percentage of his fractures in any particular way, whether it be open operation or otherwise. There are certain fractures that unquestionably are better treated by open operation and one should be able to recognize such fractures in the beginning and not leave operative treatment for a last resort.

There are other fractures which are better treated by traction, others by splinting. One should be able to tell ahead of time which method of treatment he should use. It is not fair to the patient to operate only as a last resort, because if nature has already produced a fair union, even though it be in malposition, it is asking a good deal of her to do it all over again after one has interfered in an open operation.

DR. DEAN LEWIS, of Baltimore, Md., remarked that the most common cause of non-union, interposition of soft parts, had been somewhat neglected of late. In his experience this is by all odds the most common cause. Interposition of soft parts also prevents reduction in many cases and when reduction cannot be obtained by ordinary methods, an open reduction should be made, for then the cause of non-union may be overcome.

Injury to the nutrient artery may play a rôle in non-union, especially in fractures through the shaft of the femur.

Doctor Ashhurst has brought out the fact that it is not necessary to have accurate reduction in order to obtain good functional results. This applies particularly to children, and it cannot be emphasized too often. Dr. V. C. David some years ago analyzed the results in some seventy-five fractures of the femur in children. Deformities were corrected with growth, and in some

## DISCUSSION

the extremity in which the fracture occurred was longer than the normal. Epiphyseal growth on the fractured side seemed to be stimulated.

There is one disaster that may occur with fractures which has not been mentioned, that is, Volkmann's palsy. It is a crippling disability. It is the result usually of an attempt to secure an early accurate reduction of a fracture. This palsy occurs most frequently after supracondylar fractures of the humerus and femur, after Colles's fracture, and fractures through the lower end of the fibula. It is due to venous congestion, and a subfascial hematoma in the antecubital and popliteal fossæ, interfering with venous return and the development of a collateral circulation, is the principal etiological factor.

This palsy may occur when no cast has been applied, and if palsy is threatened, the indications being pain, swelling and cyanosis of the hand, and a tense antecubital fascia, an incision should be made into the fossa to relieve the tension.

Doctor Estes has spoken about the antiseptic effect of silver. Silver wire apparently kills tissue also, for in many of the cases of non-union which he has seen silver wire has been used. No repair occurs about it and he believes that it should be discarded in the treatment of non-union and the open reduction of fractures.

DR. JOHN H. JOPSON, of Philadelphia, said that Doctor Ashhurst and he had been interested for some years in conducting a regional Fracture Conference in Philadelphia, started through the influence of the Central Committee under the leadership of Doctors Scudder and Ashhurst. He supposed the standard of practice of its members represented pretty well a cross section of the surgical practice in Philadelphia and the larger cities in the vicinity. One would get the impression, from talking to many of these gentlemen beforehand, that they were very radical in the treatment of fractures, that open operation was the only thing, and if one didn't do it and didn't stand up for it he was ultra-conservative and a back number.

He remembered very distinctly that in one of their meetings each member was asked to present his statistics for the number of cases treated by the open operation method. The surprising thing was that there was comparatively little difference in the percentage of cases which were operated on by the open method by the surgeons thought to be radical and those deemed conservative.

Doctor Scudder had made out a strong case for the operative treatment of certain fractures, supported by admirable statistics. The list of fractures which he enumerated as requiring open treatment is practically the same list which Doctor Jopson teaches his own students as requiring operation.



## GAS GANGRENE IN COMPOUND FRACTURES

By FRANK K. BOLAND, M.D.  
OF ATLANTA, GA.

FROM THE DEPARTMENT OF SURGERY OF EMORY UNIVERSITY

GAS gangrene probably is the most serious complication of compound fractures. While the treatment of the condition furnished a conspicuous part of the surgery of the World War, fortunately its incidence in civil practice usually is rare.

However, in the eighty compound fractures in negro patients treated at the Emory University Division of the Grady (Municipal) Hospital, Atlanta, during the seven years from 1922 to 1929, gas gangrene developed in fifteen cases, a percentage of 19. During the same period, in the same institution, the disease was recorded in five other cases, not compound fractures. One of these cases followed diabetic gangrene. Glycosuria has been reported as being found in gangrene due to gas-forming bacilli, but this patient was known to have diabetes before gas gangrene appeared.

During the same period I saw two cases of the malady in white patients. One was a young woman the victim of an automobile accident. The muscles of her arm were severely macerated, without fracture. The other patient was a physician who contracted the infection through a small wound in his finger received in his office. Amputation was done in the first case, and débridement in the second; both patients died.

Also, during the same period of seven years, among the ninety-seven cases of compound fractures treated in the white division of the Grady Hospital, seven developed gas gangrene, a percentage of about 7. The nature of the compound fractures in both classes of patients seemed equally severe, so that it would appear that the negro is more susceptible to the disease than the white man, or that his resistance is less.

The common habitat of the various anaërobic gas bacilli is thought to be cultivated soil and animal excreta, and it may be that the apparent susceptibility of this class of negroes is due to uncleanness. On the other hand, Gage<sup>1</sup> believes that all kinds of wool and woollen goods harbor the microöganisms. He not only found gas bacilli in the wool pads interposed between powder and shot in ordinary bullets, but also grew them in cultures taken from woollen clothes just returned from a pressing club, and in samples of unused cloth taken from a tailoring establishment.

The bacteria usually described as causing the condition are: (1) *B. welchii*, or *B. aërogenes capsulatus*, called by the French *perfringens*. (2) *Vibrio septique*, probably identical with the bacillus of malignant œdema. (3) *B. œdematiens*. (4) *B. sporogenes*, neither causal nor gas-producing, but said to be most responsible for the characteristic odor of the disease. In addition to these, several other bacteria have been named as etiological factors, such as *B. fallax* and *histolyticus*. The *B. welchii*, although it is the most frequently found, and was the only organism found in this series, and is the greatest gas producer, rarely is the sole causative agent, except in cases of localized gangrene. It is by symbiosis, the combination of two or more of these bacteria, and

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probably aërobic germs, such as streptococci, that the most virulent types of the disease are produced. The bacillus of Welch was demonstrated by smear or culture, or by both, in all these fifteen cases except two, and in these the clinical signs and history established the diagnosis. Blood cultures were tried in several cases without success.

I am indebted to Dr. Jack C. Norris, pathologist in the Grady Hospital, for the following description of cultural methods used in the detection of gas bacilli: "Material is obtained directly from the wound, either by sterile swab or sterile aspirator, and is placed into ten cubic centimeters of a fresh meat extract bouillon. This bouillon is faintly alkaline, and contains 1 per cent. dextrose. After the inoculation of the culture media, a layer of sterile liquid petrolatum, approximately 1 centimeter in thickness, is added. This oil settles over the top of the bouillon, and insures practical anaërobiosis. It is then incubated at 37.5°C.

"The culture is noted at six, eight, twelve, sixteen and twenty-four hours. The appearance of gas bubbles after six hours indicates a specific gas former. The appear-

ance of gas bubbles sufficient to penetrate the oil layer and rise to the surface is almost a positive indication of the presence of gas bacilli. Smears are made at intervals, and if the large Gram-positive bacillus is found, animal inoculations are made, and the bacteriological diagnosis confirmed.

"This method of bacteriological determination seems to be most satisfactory, especially for *B. welchii*, which is the organism usually found in this section."

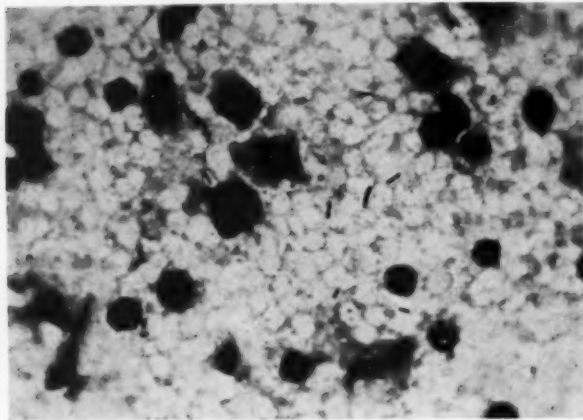


FIG. 1.—Smear from deep tissue.

The tissues attacked by these putrefactive organisms must first be damaged by direct trauma or by interference with the blood supply. While bacteria may enter the body through the alimentary canal, it is probable that in compound fractures they enter directly through the wound. While the disease is essentially one of muscle tissue, occasionally it begins in other tissues. Nearly always, however, muscle is the starting point, the infection spreading rapidly through the fibres to the end, when it attacks the next muscle beyond. The infection tends to travel longitudinally, rarely transversely.

The muscle fibres become separated from the surrounding interstitial tissue by a clear space which becomes filled with septic fluid, bacteria and gas. An X-ray film may show the gas before it is detected by crepitation. The muscle is at first dull and opaque, brick red in color, resembling cooked meat; it does not contract when pinched nor bleed when cut. Bubbles may now be pressed up and down between the fibres. Great swelling of the limb occurs, well described by Weintrob and Messeloff<sup>2</sup> as tense, not giving the fluctuation of an abscess or the pitting of oedema. The color changes to green, brown or black, a bloody exudate comes from the wound, and gas can be felt in the tissues over an area considerably greater in extent than that of the dead tissues. The characteristic odor, which must be encountered to be recognized and described, is extremely foul and sickening.

In this series of fifteen cases of gas gangrene in compound fractures, eleven patients were males, and four females; ages ranged from five to fifty-

## GAS GANGRENE IN COMPOUND FRACTURES

two years; two fractures were due to gunshot wounds; two fractures involved the upper extremity, and thirteen the lower extremity. Six patients died, giving a mortality rate of 40 per cent. No autopsies were performed. The shock of amputation apparently was the immediate cause of the demise of one or two of the patients, but since the operations were done to cure gas gangrene, and the patients would have died without such treatment, gas gangrene must be assigned as the cause of death. One of the gunshot cases died and one got well. All published series give a larger number of cases of gas gangrene in fractures of the lower extremity than in fractures of the upper extremity. Such records no doubt are due to the fact that the lower extremity is more exposed to infection from the soil than the upper extremity, and also to the fact that the tight muscles about the tibia furnish better ground for the propagation of anaerobes than the looser muscles of the forearm. Is it not also true that compound fractures are commoner in the leg than in the forearm?

Signs of the disease may be noticed in from six hours to three days after injury, the average time being about twenty-four hours. It is difficult to enumerate the different signs and symptoms in the order in which they appear. Certainly no single symptom always appears first with the regularity that pain, as stated by John B. Murphy, is always the first symptom to be noted in acute appendicitis. However, it has been commonly observed how often the first symptom of gas gangrene is a pulse rate higher than should be expected from the patient's general condition. Instead of 80 or 90, it is 110 or 120. Sometimes the temperature keeps pace with the pulse rate, and sometimes it does not. The leucocytes usually run from 15,000 to 20,000. At the same time the patient may complain that the dressing is too tight, and he seems to be restless and anxious.

At this juncture it would be better if the fracture is immobilized in an apparatus which permits easy and adequate inspection of the limb, because such an examination should be made without delay. The color changes described are not of much value in negroes. The order in which the other symptoms appear is not at all constant. Smear and culture should be made immediately, and may prove positive as early as six hours after the injury. The X-ray does not always show gas, but sometimes will demonstrate it

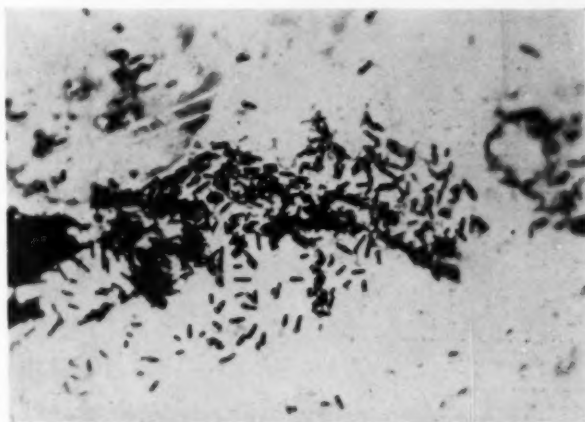


FIG. 2.—*B. welchii* shown in culture grown from case of gas gangrene. The culture is young, and spore formation does not appear.

before bubbles are seen. As a rule the odor is an early sign, but in two or three of these cases it was not definite until after the culture was positive.



FIG. 3.—Gas gangrene in gunshot fracture of knee-joint.

preserving as much skin and as many important nerves as possible. The adjacent tissues should be widely exposed to the air by multiple longitudinal incisions. Many different kinds of after-treatment have been proposed, but nothing in our hands has given better results than the application of the

The treatment of a compound fracture complicated with gas gangrene resolves itself into treating the gangrene, and treating it as promptly and vigorously as possible. If its spread is not controlled, death from septicemia, or possibly gas embolism, is almost the invariable outcome. The alignment of the broken bones can be taken care of later, and the patient will be fortunate indeed if, after he is rid of the lethal infection, there are bones to be aligned. More than likely the fracture will disappear in an amputation. Only one of these cases was cured by débridement alone, while another one was cured by débridement, and later multiple incisions. Four were cured by amputation alone, and three cured by débridement, and later amputation. Four died following débridement and amputation; one died after amputation alone; one died after linear incisions alone.

The idea of operative treatment is the excision of all obviously and supposedly damaged tissue,

## GAS GANGRENE IN COMPOUND FRACTURES

Carrel-Dakin technic. Dressings should be loose and few in order to discourage the growth of the anaërobic bacteria by the admission of oxygen.

The involved parts and the general progress of the patient should now be watched diligently. Upon the appearance of the first signs of the extension of the disease, either local or constitutional, further débridement should be done, or better a high amputation. The aim must be to save the patient's life, and not his leg or arm. In the case of the physician who died from gas gangrene of the arm, if he and the rest of us had not thought so much of how incapacitated a laryngologist would be with one arm gone, and had amputated instead of débrided, we might have avoided a mortality. The routine care of the patient's septic condition is most important. Blood transfusion does not seem to produce appreciable results.

The last eight patients in this series were given the anaërobic antitoxin of a New York firm, the first four being given the perfringens antitoxin, the last four being given the more efficient polyvalent preparation. In the last four cases the antitoxin



FIG. 4.—Gas gangrene complicating compound fracture of tibia and fibula.

was administered both as a prophylactic and therapeutic agent, the average prophylactic dose being twenty cubic centimetres, and the average therapeutic dose being fifty cubic centimetres repeated once or twice every twenty-four hours. Intravenous injections were preferred and generally employed. Two



of the seven patients who did not get the antitoxin died, and four of the eight who received antitoxin died. This sounds discouraging, but other factors must be considered. Certainly in two of the patients who received antitoxin and died, surgical shock played a large part in the fatal termination. This series is too small to draw any kind of conclusions as to the value of antitoxin in the treatment of gas gangrene, but it is evident that the virulence and rapidity of the infection differ materially among patients, whose resistance manifestly is not always the same. B. H. Clifton<sup>3</sup> reports a case from the white division of the Grady Hospital which he believes was saved by the antitoxin after shoulder-joint amputation apparently had failed.

At present all patients with compound fractures and other wounds which might give rise to gas gangrene, in addition to tetanus antitoxin are given on admission polyvalent anaërobic antitoxin as a prophylactic measure. It is advisable also that smears and cultures be taken at once. No doubt the dose of antitoxin should be larger than heretofore, probably fifty cubic centimetres as a preventative, and 100 to 200 cubic centimetres as treatment. On account of the small demand for the antitoxin its cost is high. The reactions from some of our small doses has been marked, with temperature as high as 105° and urticaria persisting for ten days.

Although the toxin produced by the tetanus bacillus is claimed to be a thousand times more lethal than that of *B. welchii*, it is difficult to conceive how the serum prophylaxis against gas gangrene can ever become as successful as antitetanic serum. The period of incubation of the gas bacillus infection is too short. The more rapid course of this disease is said to be due to a constantly occurring exhaustion of the suprarenal glands.<sup>4</sup>

Simple fractures require more consideration from the surgeon than reading an X-ray report and the application of a splint; compound fractures demand unremitting care to avoid serious contamination and give the best possible end-result, while the attention and judgment necessary to save a limb or life in a compound fracture infected with gas bacilli equals that of any problem in surgery. Lister achieved his first step toward immortal fame by his successful treatment of a compound fracture.

#### CASE REPORTS

CASE I.—Male, thirteen years of age. Admitted to the Grady Hospital (Emory University Division) November 11, 1922. Compound comminuted fracture of the left tibia and fibula, from automobile accident. Patient given 1500 units tetanus antitoxin on admission, as in all cases. Wound débrided and closed, plaster cast applied, with window. November 13, patient became stuporous, pulse rose from 100 to 142. November 15, foul odor from wound, sutures removed, bubbles of gas escaped. Smear showed *B. welchii*. Carrel-Dakin treatment instituted. Swelling and crepitation extended, general condition grew worse. November 17, high guillotine amputation of thigh. November 18, patient died. No gas-bacillus antitoxin used.

CASE II.—Male, twenty-four years of age. Admitted November 13, 1924. Compound fracture of left fibula, from fall from window to ground. Wound cleaned with iodine, cast applied. Temperature and pulse normal on admission, third day pulse 110, temperature 101°. Discharge developed typical gas-bacillus odor. Smear positive for *B. welchii*. November 18, amputation lower third of leg; December 10, secondary closure. Good recovery. No gas-bacillus antitoxin used.

## GAS GANGRENE IN COMPOUND FRACTURES

CASE III.—Female, thirty-seven years of age. Admitted December 21, 1924. Compound fracture of tibia and fibula, from automobile accident. Wound débrided and closed immediately, plaster cast applied. December 23, patient complained of severe pain in leg, temperature 99°, pulse 80. Dressing removed, typical odor and discharge discovered. Smear positive for *B. welchii*. December 25, guillotine amputation lower third of thigh; patient died same day. The pulse and temperature appeared to be but little affected by the disease. No gas-bacillus antitoxin was given.

CASE IV.—Male, six years of age. Admitted July 11, 1926. Compound fracture of right ulna, from being hooked by a cow. Patient began to complain of severe pain a few hours later, when his mother noticed marked swelling of forearm, and brought him to the hospital at once. On admission, which was not more than six hours after the injury, temperature was 101°, pulse 110; child was very restless, and general condition was poor. One hour later temperature was 103°, pulse 130, respiration 30, leucocytes 17,600, polymorphonuclears 88 per cent. Gas-bacillus odor was present, and the swelling extended to the middle of the arm, and to the wrist. X-ray showed fracture of the ulna, and gas in the tissues. Amputation was done the same day. The patient's temperature dropped to normal, and remained practically normal the six weeks he was in the hospital. Unfortunately a culture was not made from the wound until the second day, when it showed a long Gram-positive bacillus with some spore formation, morphologically consistent with *B. welchii*. No gas-bacillus antitoxin was given. Recovery was satisfactory.

CASE V.—Female, fifty-two years of age. Admitted September 1, 1926. Compound fracture of left tibia and fibula, from street accident. On admission, two hours after injury, crepitation was felt in the surrounding tissues, but no gas bubbles could be expressed. A smear taken at this time was negative. Leucocytes 18,160, polymorphonuclears 90 per cent. Débridement, closure of wound with drainage, application of plaster cast. September 4 patient had well-developed gas gangrene, with positive culture; guillotine amputation was performed in the lower third of the thigh. October 26, stump was skin-grafted. Recovery. No gas-bacillus antitoxin.

CASE VI.—Male, twenty-one years of age. Admitted December 13, 1926. Compound fracture of tibia and fibula, from truck accident. Leucocytes 12,575, polymorphonuclears 93 per cent. Wound débrided, plaster cast applied. The next day the swelling and odor suggested gas-bacillus infection, and smear was positive. Patient discharged to another hospital, and reported as a recovery.

CASE VII.—Male, eighteen years of age. Admitted July 13, 1927. Compound fracture of right tibia and fibula, from motorcycle accident. Amputation a few hours later. Temperature and pulse normal until forty hours later, when temperature rose suddenly to 102.4°, and pulse 128. Leg swollen, with foul, putrid odor, no crepitation. Smear and culture showed Welch bacillus, and later crepitation appeared. July 16, second amputation, above knee; July 27, third amputation. Recovery. No gas-bacillus antitoxin given.

CASE VIII.—Female, five years of age. Admitted August 16, 1927. Compound fracture of upper extremity of left femur, and left fibula and tibia, from being struck by a truck. Débridement of wounds, application of Thomas splint. Twenty-four hours later temperature was 105°, wounds had swelling, odor and crepitation of gas gangrene; definite Welch bacillus grew on culture. Smear also positive. Fifty cubic centimetres of perfringens antitoxin (not polyvalent) given intravenously, thigh amputated; patient died two hours later, apparently from shock.

CASE IX.—Male, thirteen years of age. Admitted September 8, 1927. Compound fractures of both legs, from street-car accident. One hour after admission right leg was amputated, left leg débrided. Next day temperature was 102°, patient very restless, definite crepitus, no odor. Smears from both legs showed *B. welchii*. Ten cubic centimetres perfringens antitoxin given intravenously. Second amputation next day; patient apparently died from shock.

CASE X.—Male, thirty years of age. Admitted December 15, 1927. Compound

fracture of knee-joint, from gun-shot wound. Débrided and splinted. Twenty-four hours later temperature was 103.8°, pulse 120; patient had anxious expression; there was bloody drainage, but no gas, and smear was negative. The next day there were crepitation and foul odor, and smear and culture were positive; temperature was 102°, and pulse 140. Thirty-five cubic centimeters of "double strength" antitoxin given, and guillotine amputation middle half of thigh performed. Temperature then dropped to 97°, pulse 160. One-hundred cubic centimeters of antitoxin given daily for four succeeding days. Recovery. After the amputation a rabbit was injected with six cubic centimeters from the stump, and killed immediately. The *B. welchii* was recovered from the peritoneum. Twelve hours after death the rabbit was enormously distended, and gave the characteristic odor of gas-gangrene.

CASE XI.—Female, twenty-six years of age. Admitted February 12, 1928. Compound fracture of right tibia and fibula, from auto accident. Amputation immediately, just above knee. The next day temperature was 103°, pulse 140, but there was no odor nor bubbles from the wound, and the smear was negative. February 14, the smear was positive, although the odor and crepitation were not marked. Patient was given fifty cubic centimeters of double strength perfringens antitoxin every twelve hours for three doses, and recovered.

CASE XII.—Male, sixteen years of age. Admitted June 19, 1928. Compound fracture of both legs, from fall in attempting to "swing" freight train. Both legs amputated below knees. Two days later there were sero-sanguinous discharge from the wounds, and suggestive odor. The next day the X-ray showed gas in both stumps, and the culture was positive from the left leg, and negative from the right leg. Ten cubic centimeters of polyvalent anaërobic antitoxin administered on admission, and for the two succeeding days, after which fifty cubic centimeters was given daily for three days. Later necrosed bone was removed from the stump of the left leg, followed by a third operation for grafting skin. After seven months in the hospital the patient was discharged as well.

CASE XIII.—Male, forty years of age. Admitted August 5, 1928. Compound fracture of left fibula and tibia, from motorcycle accident. Débrided two hours later. Twenty cubic centimeters of polyvalent anaërobic antitoxin given on admission. The next day swelling, pain, crepitation and odor were present in the wound, which was treated by multiple, longitudinal incisions, fifty cubic centimeters antitoxin being administered daily for three days. Smear and culture the second day were positive. Recovery.

CASE XIV.—Male, twenty-five years of age. Admitted August 5, 1928. Compound fracture of both legs, from automobile accident. Wounds cleaned with iodine, Dakin treatment instituted, plaster cast applied. Two days later positive culture from left leg; treated by multiple longitudinal incisions. August 6, seventy cubic centimeters of polyvalent antitoxin administered; August 7, fifty cubic centimeters; August 8, patient died.

CASE XV.—Male, twenty years of age. Admitted October 14, 1928. Gun-shot compound fracture of right ulna and radius. Twenty-four hours later odor, crepitation and bubbles of gas appeared, although culture was negative. October 16, amputation. Fifty cubic centimeters of polyvalent antitoxin given October 15, 16, and 17; October 19, patient died.

## REFERENCES

- <sup>1</sup> Gage, I. M.: Gas Bacillus Infection. *The American Journal of Surgery*, vol. i, No. 4, pp. 177-184.
- <sup>2</sup> Weintrob and Messeloff: Gas Gangrene in Civil Practice. *Amer. Jour. Med. Sci.*, vol. clxxiv, pp. 801-819, December, 1927.
- <sup>3</sup> Clifton, B. H.: Gas Bacillus Infection. *Jour. Med. Assn., Georgia*, vol. xviii, No. 4, pp. 143-145, April, 1929.
- <sup>4</sup> Van Gehuchten, P.: Organs of Internal Secretion in Experimental Gaseous Gangrene. *Ann. de l'Inst. Pasteur*, vol. xxxv, pp. 396-420, June, 1921.

## DISCUSSION ON FRACTURES

DISCUSSION: DR. FREDERIC W. BANCROFT, of New York City, said that usually trauma is a very big factor in the development of gas gangrene, but he could report three cases of gas gangrene that occurred in a Municipal Hospital of New York through simple hypodermic injection. Two were treated by an ambulance surgeon and developed gas gangrene with amputation of the arm and death; another one was possibly treated by an outside doctor when the ambulance was sent for, and came into the hospital and developed gas gangrene.

With three such dire complications from hypodermic injections, it would seem advisable to warn the hospitals to inspect their hospital bags to see that their hypodermic solutions are kept sterile. Oddly enough it was a solution of digitalis that was responsible for two of the above cases.

DR. KELLOGG SPEED, of Chicago, Ill., said that during the war in 1916 while working in the No. 18 General Hospital, B. E. F. France, Davis of Chicago first made these discoveries about the finding of gas bubbles in the X-ray examination of incipient stages of gas gangrene.

Sometime later the speaker treated and reported a series of cases thus infected by a method of muscle group excision. That saves amputation. One may have to take off a whole group of muscles, such as the extensor groups in the arms or legs because the infection spreads through and along the fascial planes, through the muscle itself not via the lymphatics in the early stages. It does not spread by the blood stream in the early stages. Consequently, if the diagnosis is made early the area traumatized with resulting gas infection, the soft parts which were penetrated, involving only a certain portion of the limb, one or two muscles, may be completely removed, or the area of infection may be completely removed simply by taking out that muscle from origin to insertion and leaving the wound wide open and treating it with the Carrel-Dakin method.

DR. URBAN MAES, of New Orleans, La., remarked that Doctor Boland had referred to some work done by Doctor Gage in the speaker's service in New Orleans. He would supplement that by recounting several things that he followed in regard to the prophylaxis of gas gangrene.

A very interesting observation has been made—it has a seasonal incidence in the South. It occurred only at a certain time of the year in people who were wearing woolen clothing at the time they were injured. In the summer, when linen clothes are worn, he had never seen a patient afflicted with gas gangrene who was hurt while he was dressed in linens; always it has been woolen clothing.

He wished also to record in line with what Doctor Bancroft had said, the fact that he had lost two patients from infection such as the type he speaks of, one from a hypodermic injection and another from an infected burn in which the blister broke and the patient was between woolen blankets. In both instances he cultured the wool from the blankets and in both instances recovered the gas bacillus.

It is interesting to bring out the fact that prophylaxis, which is the only



## DISCUSSION

safe thing to consider, has largely to do with the matter of contamination with wool in the form of clothing or blankets or other such commodities.

DR. HENRY H. M. LYLE, of New York City, said that in 1916 he reported a case of general gas gangrene without local manifestations. A French soldier was wounded in the thigh by a shell fragment. The fragment could not be found in the wound. The wound was treated by the Carrel method and remained sterile. X-ray examination of the upper thigh and lower abdomen showed no shell fragment. It was then assumed that the fragment had been extracted at the dressing station or had fallen out during transportation. On the third day the patient developed symptoms of generalized gas gangrene and he died on the afternoon of the fifth day. At autopsy the following conditions were found: A perforating wound of the left thigh, a penetrating wound of the right femoral vein, migration of a shell fragment to the right ventricle of the heart. Generalized gas bacillus infection. No local infection of the wound. The shell fragment when found in the ventricle had attached to it a portion of the uniform which was undoubtedly the source of the infection. The cardiac muscle was riddled with gas bubbles.

DR. SAMUEL C. PLUMMER, of Chicago, Ill., stressed the point in diagnosis, that the sense of smell is one that surgeons do not use very much in making diagnoses, but it can be used to great advantage in the diagnosis of gas gangrene. The number of these cases which one sees in civil practice is very small, but a short time before the war he had two cases within a few months of each other. The first of these cases was a compound fracture of the thigh with severe injury to the soft parts. This patient died after an amputation of the hip. The next one was a crushing injury of the upper arm. The arm was practically amputated by the accident. A trimming up was done and the stump left wide open and treated with a wet dressing. On the second day the speaker noticed an odor which was familiar to him from the previous case of gas gangrene. The ends of the crushed muscles which remained were partly devitalized. There was a dark, rather disagreeable color and the odor was that of rotting meat. A smear taken at once showed the presence of the Welch bacillus. An amputation was done promptly only about two inches above the amputation which was already there. This brought them into good, live tissues with good circulation and the man never developed any further symptoms of gas gangrene. He suggested where one has cases of injuries where gas gangrene is likely to occur that one does not overlook the sense of smell in making an early diagnosis.

DR. ASTLEY P. C. ASHHURST, of Philadelphia, confirmed what Doctor Plummer had said about the sense of smell. It is a good thing when you know what the smell of gas gangrene is like. It smells somewhat like a mouse.

During the second battle of the Marne he was in the American Ambulance in Paris. Patients had been coming in so fast and the staff was so small that the patients had accumulated in great numbers. It became his habit



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whenever he got a spare moment between operations to wander around the corridors and smell the patients. Those that smelled like mice he operated on right away because they had gas gangrene. The rest of them could wait awhile.

One more point: When he was a student his father lectured to his students on surgery of all kinds. He described eloquently the *Erysipèle bronzé* of Velpeau; but the speaker had to wait twenty years before he saw a case, though he knew that it must exist because his father had described it. Over in France with the French army, in the early part of the war, he operated on a patient with a compound fracture of the femur, and it was there that he saw the *Erysipèle bronzé* of Velpeau. There were no blisters but it was an erysipelas nevertheless. The disease was in the skin, and perhaps in the subcutaneous tissues a little bit. There was a distinct raised margin next the surrounding unaffected tissues. Under conservative treatment the patient recovered.

In his service at the Episcopal Hospital of Philadelphia a few years ago was a young woman with a compound fracture of the upper extremity. She developed gas gangrene, and along with it the typical bronzed erysipelas of Velpeau. The limb was so rotten that amputation was required. She recovered. That was the only manifestation of gas gangrene of that type he had ever seen in civil life.

Formerly these clinical states were classified as separate diseases, but it is much simpler not to divide them, but to class them all as gas gangrene, whether they be the acute mephitic gangrene of bone of Liddell, or the acute purulent œdema of Pirogoff, or the bronzed erysipelas of Velpeau.

## TUBERCULOSIS OF THE PERITONEUM

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IN THE last thirty years we have learned much about tuberculosis, its cause, method of transmission and prevention. Three decades ago, 200 deaths each year out of each 100,000 persons were caused by tuberculosis; today the number is less than half that. However, tuberculosis is a great economic burden; often, it causes a loss of years of health, and although the death rate has been checked, nearly as many persons as ever have the disease in some form. Besides tuberculosis in human beings, we gradually have learned of the bovine type and its methods of transmission to man through milk. Thus, tuberculosis of the bovine type, which represents at least 25 per cent. of the tuberculosis of children, is now found on farms, and in small towns and villages. In such places, frequently, there is no opportunity to secure pasteurized milk from tested, tuberculosis-free dairy herds. We also have learned of avian tuberculosis, and recently the veterinarians have shown that most tuberculosis in hogs is now classified as of the avian type. Only a few cases of avian tuberculosis have been seen in the human being. When it does occur, it most frequently affects the spleen and liver.

It is only through education of the public, by which it has been instructed in the development, transmission, and prevention of disease, that the medical profession has been enabled to control many diseases. Without this teaching of the public, it would be impossible to put into effect the great amount of knowledge that is now possessed concerning preventable disease.

In England and in Scotland greater attention has been paid to the effect of bovine tuberculosis on the human being, and their statistics, I believe, are better than ours. Tuberculosis of the tonsils is often of the bovine type, and also tuberculosis of the lymph nodes, especially of the cervical region. Tuberculosis of the appendix, and of the glands of the intestinal mesentery, may be foci for peritoneal tuberculosis.

From thirty to forty years ago the great surgical pathologist, Christian Fenger, did much to educate the medical profession concerning varieties of tuberculosis that are amenable to surgical treatment, and our great clinical professor of surgery, the late John B. Murphy, did much to advance information concerning peritoneal tuberculosis. Hyperplastic tuberculosis, with nodular masses involving the interior of the intestine, which often produces symptoms due to incomplete obstruction, is but rarely the cause of abdominal tuberculosis of the peritoneal type in which there are ascites and adhesions. Tuberculous peritonitis is nearly always, then, an unmixed infection. It may come from the appendix, and if so, the appendix is closed off from the lumen of the cæcum by a stricture. Then, the appendix may become perforated, and its caseating content may produce a multitude of tubercles

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which are confluent near the source of infection. A tuberculous gland in the mesentery just beneath the peritoneum may become liquefied and, finally, may burst through the peritoneum, infecting the peritoneal cavity. This causes, in the immediate vicinity of the focus, a confluent tuberculous mass which becomes less dense in areas further away from the point of rupture. In the early stage there is some pain, or at least some soreness, in the abdomen; this is before enough free fluid has collected to stop the rubbing of the tubercle on the peritoneum. The parietal layer of the peritoneum is sensitive to the rubbing of the tuberculous masses. When free fluid forms, as in pleurisy, pain is relieved. The abdomen increases in size, for there may be considerable distention with gas, and then, the serous, ascitic fluid accumulates.

Involvement of the pelvis in women is caused by tuberculosis of the oviduct. These tubes, lined with mucous membrane, if once affected will remain tuberculous until the tube is removed or is destroyed by the disease.

It was early noted that serous peritonitis, by repeated operations became converted into plastic peritonitis, and ultimately this plastic peritonitis sealed in the focal areas of disease. The trouble might be caused by a liquefied gland or, more commonly, by the oviduct, because tuberculosis is the only infection of the oviduct in which the fimbriated end is not closed. Caseating content escapes from the oviduct constantly until plastic peritonitis seals in the tubes. Today the effort is made to remove immediately such tubes and to enucleate the medial end within the muscular wall, at the cornu of the uterus. Thus, the tubes are removed *in toto*, down to the uterine mucous membrane; otherwise small tuberculous abscesses form in the muscular tissue at the cornu of the uterus. Reports of necropsies show that more than twice as many males as females are affected with tuberculous peritonitis, but probably three times as many females as males are operated on for this condition. In the last two years, 409 cases of tuberculosis of the peritoneum were seen at the clinic; 171 were treated surgically and 238 medically.

Tuberculosis of the interior of the uterus is rare. In girls, before puberty, tuberculous metritis may develop, and if it does the girls never menstruate. The internal uterine os may become closed, and the patients, who never menstruated, may be seen between thirty and forty years of age with pyometra. The liquefied uterine content is of thin, tuberculous material, and only the outer shell of the uterus remains.

It is most unfortunate indeed that of the young women who have had tuberculous oviducts with ascites, many have had both ovaries removed at the time the tubes were removed. Then, all the nervous changes that are so unfortunate ensue from such surgical procedures, and often the lives of the patients are practically ruined for a number of years. There is no more need of removing the ovary in tuberculosis of the fallopian tubes than there is of castrating the male in case of tuberculous epididymitis. Very rarely, castration of man or woman may be necessitated by injury to the ovary or testis by pressure necrosis; but seldom indeed is it necessary to remove these

important structures. In the later stages of tuberculosis of the oviducts the pathologic tissue may be felt in the pelvis by manual examination. The structures in the lower part of the pelvis often are fixed by the plastic adhesions following the ascites. In spite of the fixation, operation should be performed. By locating the fundus, one can follow out the tubes in the dissection, the intestinal adhesions can be separated, and a sufficient area of the tube can be exposed to permit its enucleation being started. Removal of the tuberculous tubes is all that needs to be done to cure the abdominal tuberculous peritonitis.

Just as MacCarty showed that approximately one in 225 chronic appendices removed is cancerous at the tip, so Margaret Warwick found, in a study of percentages of tuberculosis of the appendix, that 1 per cent. of them was tuberculous. Many physicians have come to believe that nature does about as well as intervention for these cases. They recommend good care, fresh air, proper food, and sunlight as medical or hygienic measures. Ochsner claimed that he saw about 50 per cent. of patients cured by medical care, and Allchin showed that 50 per cent. of patients were cured either by medical treatment or with very little care of any kind. Sorgo and Fritz recorded a number of cases, watched for a considerable period, in which ether anaesthesia given for half an hour to an hour, at repeated intervals, seemed to have given great benefit. Rost, in 1920, reported eight cases in which treatment was given by injection of oxygen into the peritoneal cavity after the fluid had been removed. Many cases of this sort have been reported. Most of these injections of oxygen or of air probably result in the change from a serous to a plastic type of peritonitis, resulting in the development of adhesions. In the treatment following surgical operation, ultraviolet light or sunlight applied under proper precautions, care to build up bodily resistance, and increase in the dosage of sunlight after Rollier's method are commonly employed. Such methods, of course, are merely to aid the body, in a natural way, to care for itself.

About 50 per cent. of the cases of peritoneal tuberculosis occur in the two decades of life between twenty and forty. It is of little avail to operate on children a year or two old. They usually die of the disease, but they offer an opportunity for the use of adjunct medical treatment. It is generally considered that many patients receive benefit from röntgen ray, which now is used widely in the treatment of tuberculous glands or of tuberculous areas in other regions, even when the tuberculosis apparently is not exceedingly destructive.

I wish to reiterate that, after many years of observation of tuberculous peritonitis in women, it has been shown that the majority of such cases arise from infection of the mucous membrane lining the oviducts. When the foci of the disease are eradicated, the patients may rapidly recover, and are less likely to suffer later from trouble in the lungs, although they may have quiescent disease there. In the cases in which treatment is by other methods, and the involved mucous membrane is not removed, tuberculosis often

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develops later in some other region, such as the lungs, and death results. When there is a fixed mass in the pelvis, probably tuberculous, with or without ascites, I would advise exploration even if the disease apparently is subsiding. If tuberculous tubes are found, they should be enucleated. It is inadvisable to separate extensive adhesions, because adhesions from tuberculosis of this form outside of the lumen of the bowel rarely are obstructive. With the utmost care, the surgeon should open a way through the adhesions, until the tube can be reached; then it can be enucleated readily. If, by accident, a hole should be torn in the intestine it should be closed by suture as well as possible and then the nearest adjacent bit of omentum (seldom to be obtained) should be placed against it and held there by sutures. If omentum is not obtainable, the injured area of the intestine may be covered with adjacent mesentery or intestine, so as more effectually to close the opening; then tincture of iodine should be applied and the abdomen should be closed without drainage.

### BIBLIOGRAPHY

- <sup>1</sup> Allchin, W. H.: Tuberculosis of the Peritoneum. T. C. In Allbutt and H. D. Rolleston's System of Medicine, London, Macmillan, vol. iii, pp. 957-978.
- <sup>2</sup> MacCarty, W. C.: Classification of Appendicitis and the Relation of Chronic Appendicitis to Obliteration of the Lumen, Carcinoma and Disturbances in the Gastro-hepatico-duodeno-pancreatic Physiologic System. Jour. Am. Med. Assn., vol. Iv, pp. 488-492, 1910.
- <sup>3</sup> Ochsner, A. J., and Percy, N. M.: A New Manual of Surgery, Civil and Military. Chicago, Cleveland Press, fifth edition, pp. 286-290, 1917.
- <sup>4</sup> Rost, E. R.: Preliminary Note on the Treatment of Tubercular Affections of the Enclosed Cavities, Abscesses, and Caries by Inflation with Oxygen. Indian Med. Gaz., vol. Iv, pp. 329-332, 1920.
- <sup>5</sup> Rost, E. R.: Treatment by Inflation with Oxygen of Tuberculous Affections of the Enclosed Cavities, Abscesses, Caries, Synovitis, and Fibrous Ankylosis. Brit. Med. Jour., vol. ii, pp. 978-980, 1921.
- <sup>6</sup> Sörgo Vorstand, and Fritz, A.: Ueber Behandlung der exsudativen Form von Peritonealtuberkulose mit Pneumoperitoneum. Med. Klin., vol. xvii, pp. 513-515, 1921.
- <sup>7</sup> Warwick, Margaret: Tuberculosis of the Appendix. ANNALS OF SURGERY, vol. lxxi, pp. 139-148, 1920.



## CHRONIC, NON-SPECIFIC ENLARGEMENT OF THE MESENTERIC LYMPH NODES, AS RELATED TO SURGERY

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ENLARGEMENTS of the mesenteric lymph nodes have been observed for a long time, especially those due to tuberculosis; but surgical attention has only recently been directed to chronic non-specific hyperplasia—a common and definite condition deserving careful consideration. It is met with quite frequently in laparotomies upon children and especially young adults (about 13 per cent. according to Guleke,<sup>11</sup>) although found often enough in those of middle age. Most surgeons, however, are not familiar with it and seldom consider it, either before or during operations. Even when detected it is not often properly evaluated, although it may represent the only discoverable lesion.

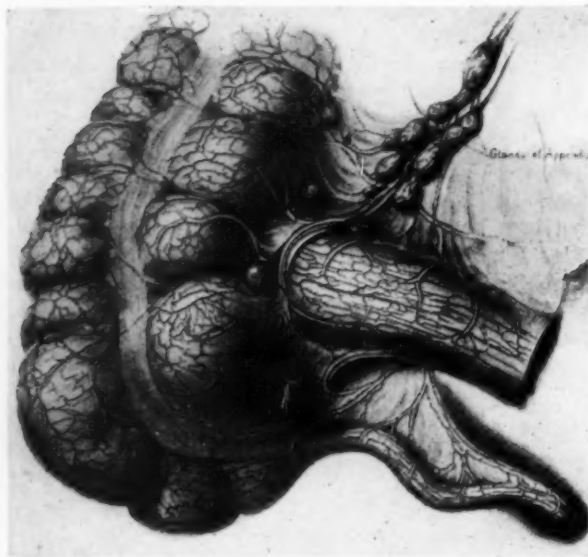


FIG. 1.—Lymph nodes of ileocecal region (appendix). (From Morris' *Anatomy*, eighth edition, p. 771.)

Probably the first papers dealing with the surgical aspects of the subject were written by Carson,<sup>6</sup> of London, in 1918, followed by Struthers,<sup>23</sup> of Edinburgh, in 1921; but both of them confused the tuberculous with the non-tuberculous form, as have all other English and most American authors. As far as I am aware, my own contribution,<sup>9</sup> in 1923, was the first in this country dealing with the surgical significance of the chronic form of the disease,

although Wilensky<sup>25</sup> published a paper in 1920 dealing with the acute, inflammatory form limited to the ileocecal angle.

Three forms of enlargement of the mesenteric glands may be recognized: (1) The chronic, hyperplastic, non-specific, non-inflammatory; (2) the acute and chronic inflammatory; and (3) the specific (tuberculous, etc.). Undoubtedly the whole question has been much obscured by confusing these

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different kinds, especially the hyperplastic with the tuberculous. This tendency has been universal in England (Carson, Struthers, Braethwaite,<sup>4</sup> etc.) and almost so in America (Wilensky, Head,<sup>12</sup> Bell,<sup>3</sup> etc.), while the Germans (Guleke,<sup>11</sup> Pribram,<sup>18</sup> Heusser<sup>13</sup>), have clearly recognized the distinction and proved it by animal inoculation and otherwise.

*Anatomy.*—The mesentery of the small intestine, with which we are principally concerned, contains from 125 to 200 lymph nodes, while that of the colon has comparatively few, the appendix having a small group of its own, within the ileocaecal angle, which is not closely connected with the others. (Fig. 1.)

Normally these nodes are too small to attract attention. Those nearest the mesenteric root are larger than those nearer the bowel. They are arranged in three groups; one close to the bowel, one near the root of the mesentery and an intermediate set. (Fig. 2.) They are made up of lymphoid elements, lymphatic capillaries, blood vessels, nerves, and supporting elements. A network of lymphatics runs to and round them, transporting lymph from the intestine, and they are well supplied with blood vessels.

There is likewise in the mesentery an extensive network of fibres of the autonomous nervous sys-

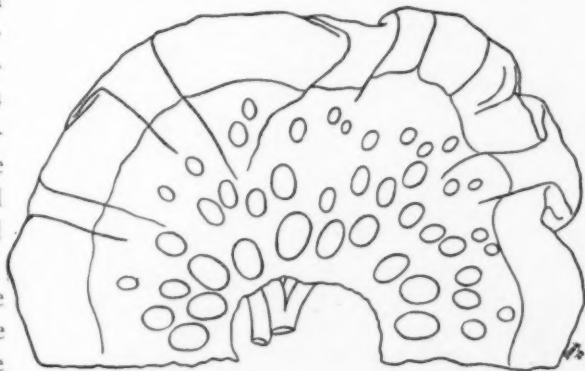


FIG. 2.—Schematic distribution of enlarged lymph nodes in mesentery of small intestine.

tem (Figs. 3 and 4), anastomosing freely with each other and sending numerous filaments to the glands, the lymphatics and the intestine (plexuses of Auerbach and Meissner). This network of nerves forms a part of the bewildering maze of sympathetic and arasympathetic fibres which, through the intermediation of ganglia, plexuses and numberless anastomoses, connect the abdominal organs with each other and with the cerebro-spinal system through the spinal ganglia (Fig. 3), thus aiding in regulating and synchronizing the various vegetative activities. It is the action of the enlarged mesenteric glands upon these autonomous nerves with which this paper is largely concerned.

*Pathology.*—In chronic, non-specific hyperplasia the enlarged glands are scattered through the mesentery of the small intestine, principally near its root and toward its distal portion (Fig. 2), and, when too much fat is not present, are easily recognized as soft, flattened, round or oval, somewhat reddish-colored bodies, elevated slightly above the surface and ranging in size from a small pea to a bean and occasionally larger. They may be few or numerous. The peritoneum is unaltered, as is usually the mesentery itself,

although the latter is occasionally thickened or shows evidences of sclerotic changes (Pribram).

These glands almost always contain no microorganisms and show no pathologic changes except simple hyperplasia. (Fig. 5.) Although the mesenteric lymphatics usually are free from apparent inflammatory changes, oblit-

erating processes sometimes exist, thus accounting for the moderate amount of ascites often observed. (Pribram.)

*Etiology.*—The trouble is found most frequently in the young, adults as well as children, occurring with decreasing frequency as middle life is attained. Those affected with it are apt to be of the neurotic type, the reasons for which will be discussed later. There are few grounds for thinking it is due to a lymphatic constitution (Heusser), to habitual constipation (Pribram), or to chronic appendicitis (Carson). Although appendicitis is found in many instances (one-half the cases according to Bagg<sup>1</sup>) it is probably a coincidence, the lymphatic system of the appendix being separate and confined to the ileo-caecal angle (Fig. 1.), while the glandular affec-

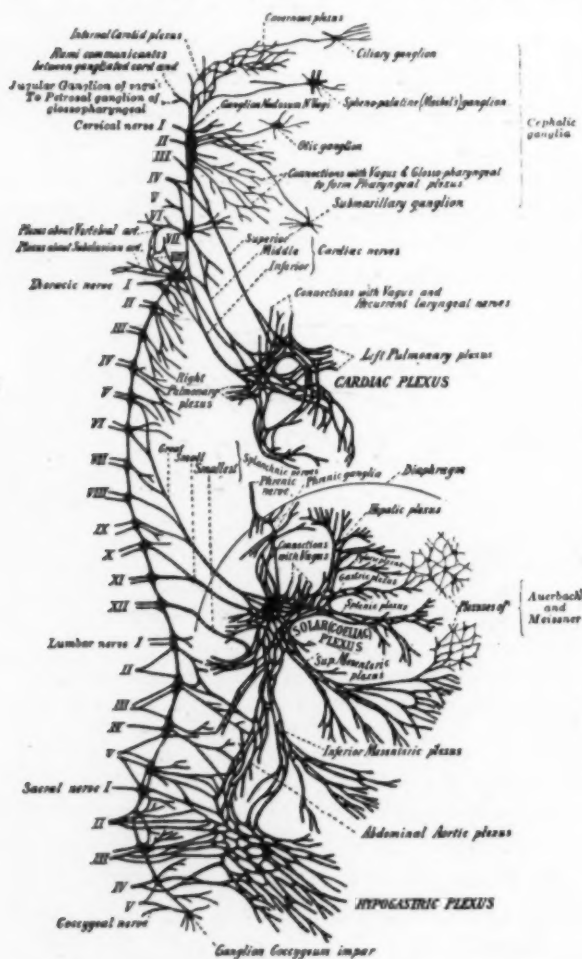


FIG. 3.—Sympathetic nervous system, showing communications with cerebrospinal system. (From Morris' *Anatomy*, fifth edition, p. 1028.)

tion under consideration is much more extensive. Melman<sup>15</sup> states that it often is found in connection with rachitis.

Most authors accept tuberculosis as the cause, as suggested by Carson. While this view undoubtedly is sometimes correct, there are reasons against it, the principal one being that evidences of tuberculosis are not often found in the glands themselves, either microscopically or by animal inoculation, the former method being, perhaps, almost if not quite as reliable as the latter. (Fig. 6.) Heusser, for instance, in twenty-five guinea-pig inoculations failed

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to demonstrate it in a single instance; and he adds that he has been able to find it only when the glands are hyaline, caseated or calcified—in other words, in those which are manifestly tuberculous to the naked eye.

During the last eight years I have observed 119 cases—thirty-one males and eighty-eight females. The greatest number, forty-seven, were between

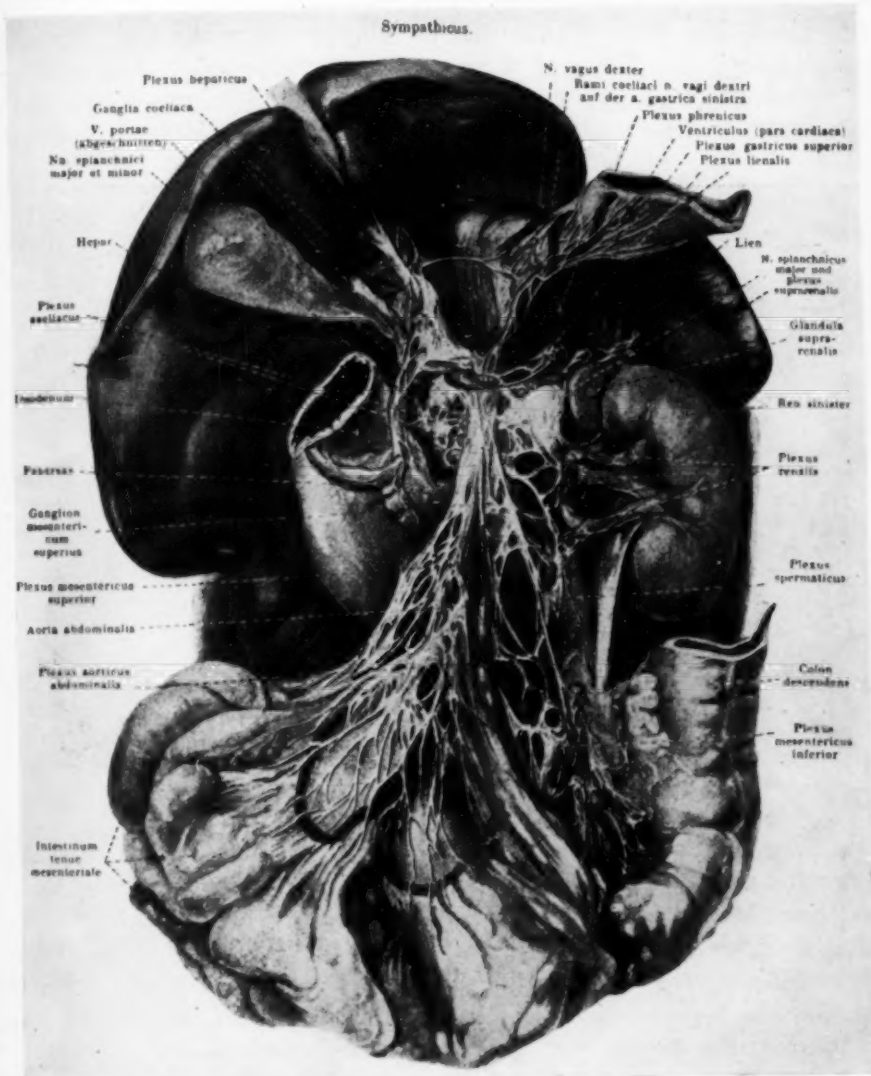


FIG. 4.—Abdominal sympathetic system. (From article by N. Guleke, *Archiv. Klin. Chir.*, B. 133, p. 529.)

twenty and thirty years of age inclusive, those above thirty numbering twenty-eight, and those between fifteen and nineteen amounting to twenty-three. Seven cases were over forty, fifteen under fifteen and eight under ten. The oldest was fifty and the youngest four. Hence it is manifest that the disease occurred most frequently between twenty and thirty years, although it

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is common enough before and after those ages. It can hardly be termed a children's disease, as has been claimed, although it belongs to the first half of life.

In ninety-two cases the glands were very numerous and in twenty-seven they were moderate in number. In eight cases they were manifestly tuberculous to the naked eye (calcification, caseation, etc.).

In about fifty cases, glands removed during operations were reported upon pathologically. Seven of these were positive for tuberculosis and the rest negative (simple hyperplasia); the positive findings occurring with a single exception where tuberculosis could also be easily detected macroscopically.

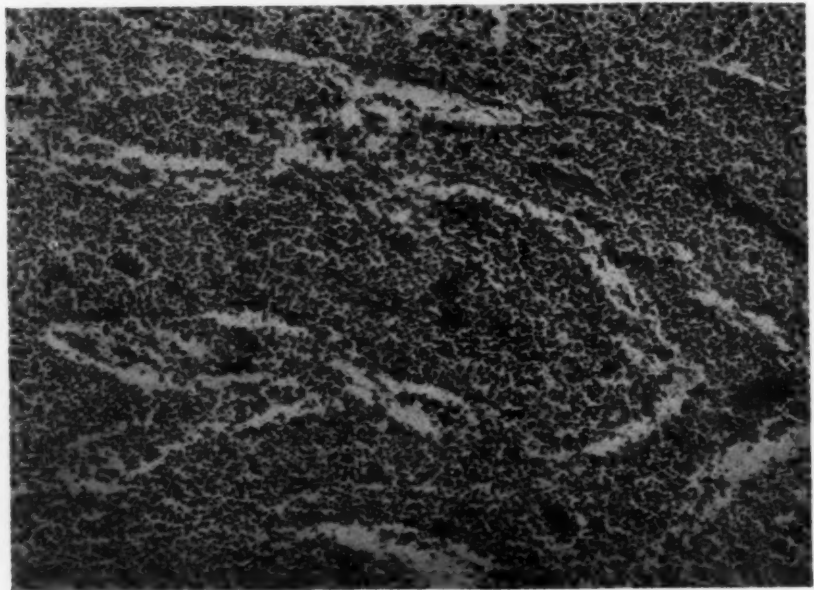


FIG. 5.—Chronic non-specific hyperplasia of a mesenteric lymph node.

pically, thus agreeing with the statements of Heusser, previously mentioned. There were, along with the histological examinations, some twenty guinea-pig inoculations, but for various reasons only about half of them could be utilized. Among these, evidences of tuberculosis were found in four; but here again the inoculations were done merely to verify a diagnosis previously made by inspection. In seventeen instances enough fluid to attract immediate attention was found in the abdomen, always when the glands were numerous.

Among various reasons for excluding tuberculosis as a cause are the self-limited character of the disease, the absence of tuberculosis elsewhere, the uniform similarity of the nodes, without caseation or calcification, and the failure of the von Pirquet test (Brünning<sup>5</sup>).

The advocates of the tuberculosis theory, however, contend that in the early stages the bacilli may be too few to find, or have died out completely, or the trouble may be due to toxins alone; but these arguments seem inade-



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quate in the face of the negative laboratory findings and the failure to demonstrate the disease in the bowel or elsewhere.

In fact, when demonstrable lesions of the digestive tract do occur, as in appendicitis, colitis, cancer, gastric and duodenal ulcer, etc., glandular enlargement is not a prominent feature, and when it is seen it is strictly regional and not widely distributed, as is the affection under discussion. In 300 cases of tuberculosis of the bowel, Winkler observed glandular enlargement only twice!

Head<sup>12</sup> and others advance the bovine bacillus as the cause, but the same arguments are valid against this as in the case of the ordinary germ,

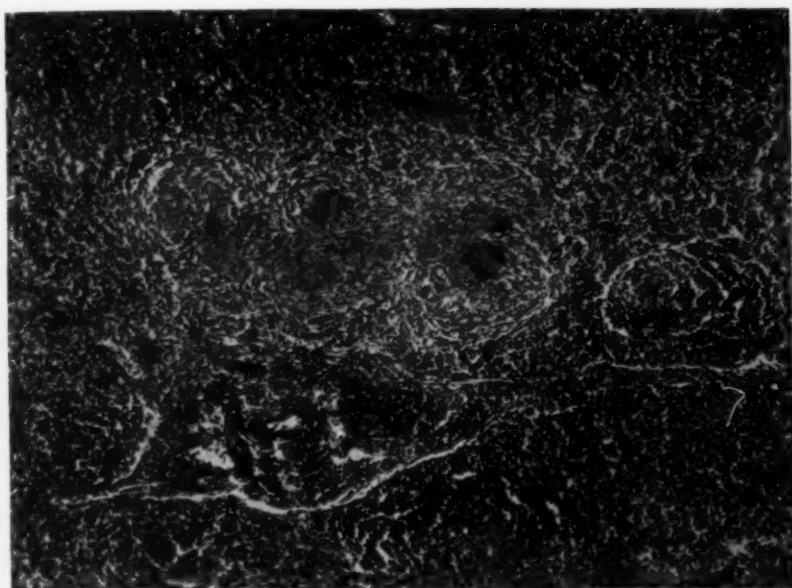


FIG. 6.—Tuberculosis of a mesenteric lymph node, showing necrotic areas and giant cells.

and in addition Shrota, of Japan, has reported twenty-four cases in which no milk had been consumed.

Because the mesenteric glands receive lymph from the intestines, it has been universally assumed that the latter are the source of the irritative material causing hyperplasia. While this theory may be true, at least partially, there are a number of objections to it:

1. The larger glands usually are not found near the bowel, but more toward the root of the mesentery. To explain this it has been assumed, without proof, that the deeper glands possess a greater susceptibility, or that the lymphatics lead more directly to them.

2. In the great majority of instances no causative bowel lesions can be found; in fact, Heusser wishes to limit non-specific hyperplasia to such cases. Some try to explain this (Pribram, Guleke, Pick) by the hypothesis that the lesions are very small, or have disappeared, while others (Pribram) affirm

that bacteria may be absorbed through the normal intestinal walls; but <sup>11</sup> this is true they should be detected more frequently in the hyperplastic nodes. Wilensky thinks that Peyer's patches may be the source of infection, likening them to the tonsils in this regard, although this would hardly account for the enlarged glands situated high up in the mesentery. Still others assert that the irritating agent is a toxin only, pointing to the fact that microorganisms are seldom if ever found in the enlarged nodes. Heusser suggests intestinal parasites as an origin for such a toxin (oxyuris, round-worms, etc.), and in this he is supported by Brünning, Loewen, Reinhardt, Hueck and Noack, and others. While intestinal parasites may be sufficiently common in Germany to lend credence to this view, although Guleke <sup>11</sup> found neither parasites or their ova in 50 per cent. of his cases, it is certainly not true of this country; in fact I have never encountered them at all, and they are seldom mentioned by other American observers. In England, Carson saw them in but four out of fifty patients. In addition, if such potent toxins actually exist, it seems they should produce more evident bowel symptoms, to say nothing of their effect upon the liver and the kidneys.

3. If the trouble is really due to the *continuous* absorption of irritating material from the bowel, the glands would scarcely remain so uniform in size and appearance, but some of them, at least, would eventually become large and hard and show evidences of inflammatory changes. One would also suppose that the greatest accumulation of enlarged glands would be in the immediate neighborhood of some assumed lesion, instead of the uniform distribution which is usually found.

The vascular origin of glandular hyperplasia has seldom been considered, in spite of the fact that various diseases, presumably through the blood, cause enlargement of glands all over the body, with a tendency to select certain susceptible groups—for instance, syphilis, Hodgkin's disease, lymphatic leukemia, glandular fever, etc.

My own case histories indicate that influenza frequently precedes mesenteric lymphadenitis. This also is mentioned by Melman and Pribram, while Wilensky says that enlargement of glands elsewhere is often encountered and Baumgarten <sup>2</sup> refers to acute glandular fever as an accompaniment. Colmers,<sup>7</sup> Edelman,<sup>8</sup> and Schmieden<sup>20</sup> also mention involvement of the mesenteric glands in *grippe*, the irritation from which may be marked enough to cause a spastic ileus. Hence I am inclined to believe that influenza and allied disturbances are responsible, through the vascular system, for chronic hyperplasia of the mesenteric glands, in many instances at least. This theory agrees with the absence of bacteria and of intestinal lesions, with the uniformity in size and appearance of the nodes, with the extent and manner of their distribution, and with the self-limited character of the disease.

*Symptoms.*—When symptoms are present, which is not always, they are often indefinite and confusing because of their functional character and dependence upon the nervous irritation of various abdominal organs. There

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are, nevertheless, certain outstanding features that deserve consideration and which often permit of at least a tentative diagnosis: \*

1. *Pain, tenderness and rigidity*, although usually present, are seldom very pronounced. They occur around the centre of the abdomen with a strong tendency toward the right iliac fossa, following, in general, the attachment of the mesentery. There also is often a nervous irritability of the muscles rendering deep palpation difficult.

Frequently the pain is colicky in character, due to spasm of the bowel, as pointed out by Carson. I have noted a striking spastic irritability of the bowel many times during operation, and believe that it accounts for some of the indefinite colics so often encountered in children. Carson states that it may cause intussusception, and has actually seen this condition develop in the course of a laparotomy. It may even result in an actual ileus in acute cases (Edelman, Colmers, Schmieden).

2. *Various dysfunctions of the digestive tract* are frequent, such as constipation, diarrhoea, flatulence, indigestion, anorexia, etc., resulting in loss of weight and energy and depending upon irritative disturbances of the autonomous nervous system. Pylorospasm is frequent, together with hepatic symptoms pointing to spasm of the sphincter of Oddi, due, according to Keppler and Erkes<sup>14</sup> to involvement of the superior mesenteric glands. The constipation may be accounted for by spasm of the rectosigmoid sphincter. (Carson.)

3. *A rise in temperature* is often present, seldom exceeding one or two degrees. This may persist for a long time; and when, in a young individual, it cannot be accounted for otherwise, a suspicion of mesenteric lymphadenitis may be entertained, especially in the presence of other characteristic abdominal symptoms.

4. *A "neurotic temperament"* is noted so frequently that it probably amounts to more than a coincidence. While several explanations for this might be offered, I believe the real cause is an irritation of autonomous nerve filaments by the lymphatic elements in the mesentery. As Guleke puts it, it is common knowledge that caseous and calcified lymph nodes can cause irritation of nerves and we are justified in assuming that simple hyperplasia may do likewise. This nerve irritation affects the adjacent intestines and is widely reflected throughout the abdomen by way of the coeliac plexus (Vorschütz<sup>24</sup>). It is also carried to the cerebrospinal nervous system through the spinal ganglia, causing irritability of the abdominal muscles by way of the spinal nerves, and it may also account for the general neurotic condition through disturbances of the higher nerve centres. (Fig. 3.)

That similar phenomena occur with other pathologic conditions is a matter of common observation; for instance in ulcer of the stomach, chronic appendicitis, mucous colitis, etc., and it also is suggestive that a reverse process is frequently met with, in which psychic disturbances give rise to inter-

\* The coöperation of Dr. J. N. Hall has been of much value in the symptomatic study of many of my cases.

nal functional disorders, notably of the stomach, intestines and ductless glands.

*Diagnosis.*—A definite diagnosis is difficult before opening the abdomen, owing to the similarity of the symptoms to those of other abdominal lesions. Nevertheless, a "good guess" may often be hazarded, although it would be unwise to place too much reliance upon it for fear of overlooking some important lesion, especially a pathologic appendix.

As diagnostic signs of more or less value, Steinberg<sup>22</sup> gives two tender points on deep pressure, one in the right hypochondriac region, easily confused with the appendix, and the other to the left of and a little above the umbilicus, opposite the second lumbar vertebra. Payr calls attention to a tender area between McBurney's point and the navel, to which he attaches importance.

In attempting to differentiate between simple and tuberculous lymphadenitis, tuberculin has been recommended (Head,<sup>12</sup> Heusser,<sup>13</sup> Brünning<sup>5</sup>), but its value is questionable except when the outcome is negative. Heusser affirms that a diagnosis of tuberculosis is hardly justifiable unless a tumor can be felt or calcified glands demonstrated by the X-ray.

In general it may be said that, confronted by a child or young adult of a nervous temperament, with more or less indefinite abdominal symptoms resembling those of chronic appendicitis, but less pronounced, one is justified in considering non-specific hyperplasia of the mesenteric lymph nodes; especially if the symptoms are long-continued, constant, and devoid of definite attacks, and if there is loss of strength and energy and a slight rise in temperature.

*Prognosis.*—Although mesenteric lymphadenitis does not seem to be a serious disease, it can be a very disturbing one. Especially in children, it may lead to nervous troubles and various internal dysfunctions having a decided bearing upon mental and physical development.

Unquestionably the trouble is self-limited, because it is found so frequently in the young and so seldom in later life, and it seems to leave no definite pathology behind it. At present we have no means of estimating how long its course actually is. Although we know that the symptoms often vanish quite rapidly after a laparotomy, as emphasized by Carson, Braethwaite, Guleke and others, they by no means always do so, thus adding one more to the numerous causes for "unsuccessful" operations for appendicitis.

*Treatment.*—Following laparotomy, which usually precedes a diagnosis, if the symptoms do not promptly disappear, further treatment should be instigated. This may consist of:

1. Hygienic measures, including proper diet, open-air exercise, cod-liver oil, etc., as indicated. Tuberculin is of course useless in simple hyperplasia, and also in the tuberculous form, according to Braethwaite.<sup>4</sup>
2. Heliotherapy and other forms of radiation, such as ultraviolet light (Head<sup>12</sup>). Bagg<sup>1</sup> says that the X-ray is of no service, and if its use is decided upon it should be employed with caution.

The appendix should always be removed, among other reasons because

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there will always arise a suspicion that subsequent symptoms may be due to its presence.

Pribram very properly emphasizes the necessity for adequate incisions, permitting careful inspection, for otherwise the disease is apt to be overlooked.

### RÉSUMÉ

1. Chronic non-specific enlargement of the mesenteric lymph nodes is a distinct affection occurring in the first half of life, especially between the ages of twenty and thirty, although common enough before and after those years.

2. In spite of its frequency, comparatively little attention has been called to it and its surgical significance is not often recognized during and after abdominal operations.

3. The hyperplastic glands, perhaps the size of a large pea, can be seen and felt, often in profusion, in the mesentery of the small intestine, beneath the unaltered peritoneum. There are usually no signs of inflammation, although fluid is often present in the peritoneal cavity.

4. The irritating agent is assumed by all writers to proceed from the bowel, although intestinal lesions can seldom if ever be demonstrated and, *vice versa* when ulcerations of the bowel exist, enlargement of the mesenteric glands is uncommon. Among possible causes are intestinal parasites and influenza (vascular origin), but the majority of writers favor tuberculosis, although evidences of the disease can seldom be found in the glands, the intestines, or elsewhere.

5. The symptoms, resembling those of chronic appendicitis, but more diffuse and less pronounced, are mainly pain, tenderness and rigidity, with perhaps a slight rise in temperature. Various local and general symptoms, such as colics, dysfunctions of the digestive tract, pyloric spasm, spasticity of the abdominal muscles, nervous irritability, etc., probably arise reflexly from irritation of the autonomous mesenteric nerves by the enlarged glands.

6. A definite pre-operative diagnosis should be made with caution, for fear of overlooking some lesion requiring operative attention, such as appendicitis.

7. The treatment includes hygienic measures and heliotherapy. Sometimes, but not always a laparotomy alone leads to rapid recovery. The appendix should always be removed, if for no other reason than because of the tendency to ascribe all subsequent symptoms to its presence.

### LITERATURE

<sup>1</sup> Bagg, K.: Beiträg. klin. Chir., vol. cxli, No. 1, p. 23, 1927.

<sup>2</sup> Baumgarten, E. C.: Surgical Significance of Acute Glandular Fever. Michigan State Med. Jour., p. 243, May, 1925.

<sup>3</sup> Bell, L. P.: (Mesenteric Lymphadenitis Simulating an Acute Abdominal Condition). Literature. Surg., Gyn. and Obstet., vol. xlv, p. 465, 1927.

<sup>4</sup> Braethwaite, L. R.: Brit. Med. Jour., p. 439, Jan., 1926; Also, Brit. Jour. Surg., p. 7, July, 1923.



## DISCUSSION

- <sup>6</sup> Brünning, F.: Lymphangitis Mesenterialis. *Archiv. Klin. Chir.*, vol. cxlv, p. 257, 1927.
- <sup>7</sup> Carson, H. W.: The Clinical Aspects of Tuberculous Mesenteric Glands. *Trans. Med. Soc. of London*, vol. xli, 1918.
- <sup>8</sup> Colmers, F.: Ueber spastischen Ileus bei Grippe. *Zentralbl. f. Chir.*, p. 1931, December 30, 1922.
- <sup>9</sup> Edelman, H.: Spastisches Ileus, Appendicitis und Darmgrippe. *Zentralbl. f. Chir.*, No. 2, p. 75, 1928.
- <sup>10</sup> Freeman, L.: Surgical Significance of Mesenteric Lymphadenitis. *Surg., Gyn. and Obstet.*, p. 149, August, 1923.
- <sup>11</sup> Freeman, L.: The Neurotic or Irritable Abdomen. *ANNALS OF SURGERY*, p. 692, November, 1924.
- <sup>12</sup> Guleke, N.: Die Hyperplasie der Mesenterial-Lymphdrüsen. *Arch. Klin. Chir.*, vol. cxxxiii, p. 517.
- <sup>13</sup> Head, J. R.: Tuberculosis of the Mesenteric Lymph Glands. *ANNALS OF SURGERY*, vol. lxxxiii, p. 622, 1926.
- <sup>14</sup> Heusser, H.: Die Schwellung der Mesenterialen Lymphdrüsen. *Beiträg. klin. Chir.*, vol. cxxx, No. 1, p. 85.
- <sup>15</sup> Keppler and Erkes: *Med. Klin.*, vol. xv., p. 301, 1919.
- <sup>16</sup> Melman, R. J.: Tabes Mesenterica Following Influenza. *N. Y. Med. Jour.*, vol. lxxii, p. 384, 1921.  
Mettenleiter, M.: Ueber primäre Mesenterialdrüsentuberculose bei Kindern. *Deut. Zeitschr. f. Chir.*, B. 199, s. 120, 1926.
- <sup>17</sup> Mühsam: *Deut. Med. Woch.*, No. 29, p. 1647, 1926.
- <sup>18</sup> Noesske: Lymphadenitis Ileocæcalis bei und nach Appendicitis. *Zentralbl. f. Chir.*, No. 43, p. 2399, 1924.
- <sup>19</sup> Pribram, B. O.: Ueber Lymphangitis Mesenterialis. *Arch. klin. Chir.*, vol. clx, p. 589, 1926.
- <sup>20</sup> Ravdin, L. S.: Retroperitoneal Tuberculous Lymphadenitis. *ANNALS OF SURGERY*, vol. lxxxiii, p. 807, 1926.
- <sup>21</sup> Schmieden: Ueber die chirurgische Erscheinungen der Grippe. *Münch. Med. Woch.*, No. 9, p. 299, 1919.
- <sup>22</sup> Speese and Klein: Acute Mesenteric Lymphadenitis Associated with Chronic Appendicitis. *Surg. Clin. North Am.*, vol. iv, No. 1, p. 261, 1924.
- <sup>23</sup> Steinberg, A.: Zur Diagnose der Mesenterialtuberculose. *Zentralbl. f. Chir.*, No. 21, p. 1326, 1927.
- <sup>24</sup> Struthers, J. W.: *Edinburgh Med. Jour.*, vol. xxvii, p. 22, 1921.
- <sup>25</sup> Vorschütz, J.: Ueber Erkrankungen im Oberbauch bei entzündlichen Prozessen im Unterbauch. *Zentralbl. f. Chir.*, No. 4, p. 217, 1929.
- <sup>26</sup> Wilensky, A. O.: Mesenteric Lymphadenitis. *Med. Rec.*, November 6, 1920.
- <sup>27</sup> Wilensky and Hahn: Mesenteric Lymphadenitis. *ANNALS OF SURGERY*, vol. lxxxiii, p. 812, 1926.

DISCUSSION: DR. DEAN LEWIS, of Baltimore, Md., asked Doctor Freeman if the blood of these patients agglutinated the bacillus melitensis. There is a possibility, he believed, that in some of these cases Malta fever may have been the disease from which these patients suffered. Physicians are recognizing that undulant fever is more common than was supposed. It manifests itself in different ways. A case of intermittent hydrops of the knee-joint recently studied at the Hopkins Hospital had undulant fever and the bacillus was grown from both knee-joints. This disease should be kept in mind in some of these obscure, indefinite lesions.

DR. GEORGE J. HEUER, of Cincinnati, Ohio, asked Doctor Freeman

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whether he had found any relationship between the condition he had been discussing and the so-called acute glandular fever which occurs sometimes in epidemic and not infrequently in sporadic form. The speaker had operated several times upon such cases under the mistaken diagnosis of acute appendicitis. The patients had presented themselves with fever, nausea and vomiting, and sometimes diarrhoea, and with marked tenderness and muscle spasm over the appendix region. The suggestion of appendicitis had been so strong that he had been unwilling not to operate on them. At operation the peritoneum had been slightly inflamed, with a quantity of clear fluid in the peritoneal cavity; the appendix had appeared normal but the mesenteric lymph nodes had shown very marked enlargement and inflammation.

The question is: What becomes of these enlarged lymph nodes that one finds at operation? Do they subside or do they sometimes remain enlarged and give rise to chronic glandular enlargement as in the cases which Doctor Freeman has cited? His particular question was whether in the past history of his patients Doctor Freeman had obtained a history of acute illnesses which suggest acute glandular fever?

DR. HUBERT A. ROYSTER, of Raleigh, N. C., said that he was familiar with the work of Doctor Freeman with respect to mesenteric lymphangitis and his study of the irritable abdomen. He was also familiar with the work of Wilensky who studied this question in children very thoroughly. He had had occasion to review all of these in relation to six cases of this type of infection which he had had in the past few years. In all of these cases the diagnosis of appendicitis was made, save one; in the last one they suspected the lymphangitis on account of the study of the previous ones.

He was satisfied that some of these were due to lymphatic block around the appendix, and the removal of the appendix mechanically releases the block. He was also perfectly satisfied that Doctor Heuer's suspicion was right in regard to the so-called glandular fever, because the last case the speaker had, even after the removal of the appendix, went on with a regular course of the so-called glandular fever. A study of the blood developed the mononucleosis which is characteristic of this infection. All of the cases got well after having the appendix removed. As to the suggestion of Doctor Lewis, there have been a few cases of undulant fever developing in children, showing the signs of mesenteric lymphadenitis.

DR. FRANK S. MATHEWS, of New York, recalled a number of cases seen in the last two or three years with large and calcified lymph nodes, which had come with a variety of diagnoses and had in some cases had operations advised under the diagnosis of kidney or gall-stones or chronic appendicitis. Some had already had their appendix removed. One point about these patients with chronic nodes had impressed him, namely, that they had symptoms (chiefly pain) which seemed to depend on the presence of the nodes. They had not been definitely characteristic of either an appendix, gall-bladder or a kidney stone. In two there had been a history of slight hematuria and once a

## DISCUSSION

history of jaundice. In two cases, he had removed a fair-sized single calcified node with relief of the symptom of which the patient complained.

DR. LEONARD FREEMAN (in closing the discussion) said the question of glandular fever had been taken up quite elaborately by Baumgarten who published it in this country sometime ago in the *Michigan State Medical Journal*, 1925. Personally he did not know much about undulant fever. He had never gotten any history of it, but he stated in his paper that various forms of acute diseases that may occur can cause, through the blood perhaps, enlargement of the mesenteric glands.

As to calcified glands causing symptoms, calcified glands are perhaps always tuberculous. At least one has a right to consider that they have been so. So they would hardly come under this heading. But the point is interesting that calcified glands, as well as other enlarged glands, do cause symptoms and that is one reason one has for considering that these enlarged hyperplastic mesentery glands may also be the cause of the symptoms that seem to go with them.

## THE SURGICAL TREATMENT OF BILE TYPHOID CARRIERS

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It is almost trite to state that one of the outstanding accomplishments of preventive medicine was the practical elimination of typhoid fever from the war zone during the late World War. The two reasons for this great triumph in sanitation are: first, all individuals engaged in the war zone were immunized by vaccination against typhoid; and secondly, military law and public opinion and coöperation made possible the enforcement of drastic measures necessary to the detection and elimination of the typhoid carrier.

Unfortunately in peace time, with the general public, compulsory vaccination against typhoid, and the early detection and close and constant supervision of the typhoid carrier are exceedingly difficult. For these two reasons typhoid continues to be endemic. According to the Metropolitan Life Insurance Company<sup>1</sup> there occurred in the United States in 1926, 41,377 cases of typhoid with 7614 deaths and in 1927, 34,411 new cases with 6525 deaths. Garbat<sup>2</sup> states that, in the period of 1920 and 1921, about 150,000 typhoid cases were reported in the United States with a production of approximately 7500 carriers. There are still many hospitals in this country where the typhoid convalescent is discharged to the community without proper steps being taken to determine the question as to whether or not he is a carrier.

The study of the typhoid carrier may be said to have been initiated by Robert Koch,<sup>3</sup> who in 1902 first called attention to the typhoid patient or convalescent as the most serious source of the spread of the disease. Frosch<sup>4</sup> first proposed the theory that the typhoid bacillus may play a saprophytic rôle in the intestinal tract over a long period and this hypothesis was confirmed by the bacteriological studies of Drigalski.<sup>5</sup> He was the first to trace a convalescent to the chronic carrier state. It soon became evident that the carrier spread the bacillus in both urine and fæces, and this led to an active study of the best media to be used for the rapid detection of the bacilli in the excreta of typhoid convalescents.

Investigations, both clinical and experimental, point to the gall-bladder as the nidus of the typhoid bacillus both during the disease and long after. Fütterer<sup>6</sup> in 1888 first showed that the bacillus could be isolated from the gall-bladder in fatal cases of the disease. Longcope<sup>7</sup> took bile cultures as a routine in suspected typhoid deaths at the Pennsylvania Hospital and found the typhoid bacillus regularly in all positive cases. The gall-bladder has been shown to be the nidus of infection in the chronic typhoid carrier state, experimentally produced in the rabbit. Blochstein<sup>8</sup> first showed that rabbits given intravenous injections of typhoid cultures gave positive cultures of the bacilli

in the gall-bladder weeks after the injection. Gay<sup>9</sup> was able to produce the carrier state in normal rabbits by intravenous injection of typhoid bacilli in 90.6 per cent. of the forty-three animals used.

The presence of gall-stones in the chronic typhoid carrier, both human and in the experimentally produced state, is an outstanding feature and is significant in that the presence of a porous, foreign body in the gall-bladder makes it next to impossible for the gall-bladder bile to become sterile. In the combined twenty-eight cases of Haalands and our series of carriers operated upon, 90 per cent. showed gall-stones, some of them as early as three months after the disease. Pratt<sup>10</sup> reports a case of gall-stones removed on the eighteenth day of the fever. The bacilli may persist for years after the typhoid. The writer, when House Surgeon at the Roosevelt Hospital, cultured the stones in a case of gall-bladder disease operated upon by Dr. Charles N. Dowd. Active pure cultures of *B. typhosus* were obtained from the centre of all three of the large stones. The patient had had typhoid fever thirty-two years previously.

The problem of the carrier state in the transmission of infectious diseases has been thoroughly discussed by Sacquépée<sup>11</sup> and by Ledingham and Arkwright.<sup>12</sup> Gay<sup>9</sup> summarizes their findings and adds his own wide experience in his discussion of the typhoid carrier in his Monograph on Typhoid Fever. The reader is referred to this chapter for a detailed review of the literature to 1918.

The most extensive and careful study of the typhoid carrier from the standpoint of the pathogenesis of the carrier state is that of Garbat<sup>2</sup> published in 1922. This analysis is based upon the study of 164 typhoid cases occurring in the internment camp for German civilian prisoners at Hot Springs, N. C., in 1918. Because these patients, cared for in the Military Hospital in Asheville, were under military control it was possible to carry out certain procedures like duodenal intubation and frequent bacteriological examinations, both during convalescence and for weeks afterward that would be next to impossible in a civilian community.

Garbat's studies corroborated the work of other investigators that the carrier distributes bacteria either through the urine or the fæces, or both. The urine carriers will not be reviewed in this discussion. Suffice it to say that the urine carriers clear up much more rapidly and in only about 1 per cent. of all typhoid cases does the bacilluria continue for as long as two to three months. His study of the fæces carriers is his most important contribution to the problem of typhoid dissemination. He demonstrated that there are three distinct types of fæces carriers, according to the nidus of infection: (a) liver, (b) gall-bladder, (c) intestine. In the first two the bacilli enter the intestine with the bile. In the intestinal type the bile passages are free of infection.

Of these 164 typhoid cases thirty-nine, or 21 per cent., showed *B. typhosus* in the fæces during convalescence. There were in addition fourteen cases in whom duodenal intubation cultures revealed the bacilli after three con-



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secutive stool cultures had been proven negative. That is, there were fifty-three, or 32 per cent., of the 164 cases that proved to be carriers for varying periods of time after the temperature had reached normal. Of these, 28 to 29 per cent. were temporary carriers while 3 to 4 per cent. became permanent carriers. These studies proved beyond question that duodenal intubation culture was a much more reliable method of determining the bile carrier state than stool culture. Garbat showed that stool cultures fail to detect the bacilli in 15 per cent. of the carriers.

In the intestinal carriers bile cultures show no typhoid bacilli whereas the stool cultures show a heavy growth. This type of carrier is exceedingly rare. The great majority are bile carriers, and the great majority of the bile carriers are gall-bladder carriers. It is possible to differentiate the intestinal carrier from the bile carrier by duodenal intubation and stool cultures, but it is impossible to differentiate the two types of bile carriers, *i.e.*, duct or liver or gall-bladder types. It is most important to try to establish the type of faeces carrier during convalescence, *i.e.*, at the beginning of the carrier state. At this stage the intestinal is readily differentiated from the bile carrier. If the faeces carrier shows on two or three consecutive days an absence of bacilli in the duodenal bile the carrier must be observed as an intestinal carrier and surgery is not indicated as it is in the bile carrier.

It must be again emphasized that the detection and control of typhoid carriers is far more difficult in civil life and in peace times than in a military hospital or under a military régime. The menace of a carrier and the difficulties of dealing with an ignorant and obstinate individual are well portrayed in the fascinating detective story of "Typhoid Mary," published by her discoverer, Dr. George A. Soper.<sup>13</sup> Typhoid Mary, as a cook, was responsible for ten known outbreaks of typhoid fever. The total number of her known victims was fifty-one. Owing to the fact that only parts of her entire history and whereabouts are known it is probable that the total number of outbreaks for which she is responsible is much larger than the record indicates. Dr. William H. Park<sup>14</sup> states that she is now isolated at the Riverside Hospital in New York City. She has consistently refused to have her gall-bladder removed.

In New York State, not including New York City, the State Department of Health<sup>15</sup> has listed at the present time 204 active typhoid carriers. They are under supervision, are not allowed to engage in any food handling occupation, but they are scattered over the state and are not under military control. Last year alone twenty new carriers were discovered and added to the active list. One of these carriers had had typhoid thirty-seven years previously.

No cure for the bile carrier state by any means other than cholecystectomy and drainage of the common duct has as yet been discovered. Dehler<sup>16</sup> was the first to use surgery in the therapy of the carrier state. In 1907 he performed two cholecystostomies; one was cured, the other remained a carrier. Since then isolated cases or small groups of cases have been reported

with varying success. Fromme<sup>17</sup> summarized the results of surgery in the treatment of the typhoid carrier state up to 1910.

The lack of a more positive stand for surgery in dealing with these unfortunate individuals is chiefly due to two factors: (1) Some of the carriers operated upon with cholecystectomy or cholecystostomy have continued to be carriers. (2) The operations may have been done by incompetent surgeons in asylums or state institutions with a high mortality—a much higher mortality than is seen in well-equipped and well-manned general hospitals—and there has been created a prejudice against advising surgery. Thus in the New York State Department of Health<sup>15</sup> Doctor Roberts says, "We refrain from advising any carrier to have a gall-bladder operation on account of the considerable operative risk involved. Carriers, however, who wish to have such an operation performed, may receive treatment at the expense of the State."

A report from the New York State Department of Health, dated April 25, 1929, summarizes the results of gall-bladder operations on typhoid carriers in New York State, exclusive of New York City:

|   |    |
|---|----|
| Known carriers considered to be cured by operation.....                                       | 14 |
| Known carriers probably cured by operation .....  | 2  |
| Known carriers not cured by operation .....   | 5  |
| Known carriers who died after operation before results<br>could be determined .....           | 5  |
| Other known carriers whose gall-bladders were removed<br>but results not yet determined ..... | 3  |
| Carriers discovered after gall-bladder operations .....                                       | 5  |
| Total .....   | 34 |

The following is a report from the New York City Board of Health on Bile Typhoid Carriers operated upon with cholecystectomy and recorded in the New York City Board of Health:

"Our present knowledge of these carriers is much too meagre to draw any conclusions. We have records of seven cases operated upon for removal of the gall-bladder, to remove the carrier condition. Of these seven, three have disappeared from our view, two having absconded and the third is now living in New Jersey; she is one of the cases operated upon by Doctor Whipple. The stool findings in our seven cases show as follows:

"Carrier No. 17.—Stools examined after operation show: positive, 0; negative, 10; no growth, 1.

"Carrier No. 111.—Stool examinations since operation, 5: positive, 3; negative, 2; no growth, 0.

"Carrier No. 119.—Stool examinations since operation, 3; positive, 1; negative, 2; no growth, 0.

"Carrier No. 401.—Stool examinations since operation, 11: positive, 1; negative, 10; no growth, 0.

"Carrier No. 421.—Stool examinations since operation, 7: positive, 0; negative, 7; no growth, 0.

"Carrier No. 479.—Stool examinations since operation, 113; positive, 74; negative, 39; no growth, 0.

"Carrier No. 397.—Stool examinations since operation, 2; positive, 0; negative, 2; no growth, 0.

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"In view of the fact that many typhoid carriers are intermittent and some of them have negative stool findings for a number of years, it would be necessary to have statistics covering a long number of years before any definite conclusions could be drawn. Of the seven cases we have listed, four had at least one positive stool after operation.

"The attitude of the department, of course, is to keep watch on any cases which have been operated upon, hoping that sometime in the future we may be able to draw some definite conclusion in the matter of dropping them from our list of carriers as cured." At present there are some 260 active carriers listed in the New York City Board of Health.

### HAALAND SERIES

|  |    |                                    |    |    |
|--|----|------------------------------------|----|----|
| Cases operated upon for carrier state..... |    |                                    |    | 14 |
| B. typhosus.....                           | 5  | Males.....                         | 1  |    |
| Paratyphoid B.....                         | 9  | Females.....                       | 13 |    |
| Cholecystectomy.....                       | 13 | Survived.....                      | 13 |    |
| Cholecystostomy.....                       | 1  | Died(sixth day)withcholecystectomy | 1  |    |

#### Results:

|                                       |    |
|---------------------------------------|----|
| Cured by bacteriological control..... | 11 |
| Remain carriers.....                  | 2  |

#### Analysis of fourteen cases operated upon at Presbyterian Hospital:

|                    |    |              |    |
|--------------------|----|--------------|----|
| B. typhosus.....   | 13 | Males.....   | 3  |
| Paratyphoid B..... | 1  | Females..... | 11 |

|                                      |   |
|--------------------------------------|---|
| Known carriers before operation..... | 8 |
| Considered cured.....                | 6 |
| Remain carriers.....                 | 2 |

Probable carriers because of finding bacilli in gall-bladder bile, stones or gall-bladder tissue cultures at operation..... 6

|                    |   |
|--------------------|---|
| B. typhosus.....   | 5 |
| Paratyphoid B..... | 1 |

|   |   |
|---|---|
| Considered cured.....                             | 3 |
| Not followed (bacteriologically).....             | 1 |
| Remained a carrier.....                           | 0 |
| 2 died—third and seventeenth day after operation. |   |

#### Of the two cases with cholecystostomy:

- One cured—stools examined at 1, 16, 36, 60 and 85 months.
- One remained a carrier during Board of Health follow-up of three years.

#### Of the twelve cases with cholecystectomy:

- Two died. Both had cholangitis and pancreatitis at time of operation.

#### Of the ten surviving cases:

|                             |   |
|-----------------------------|---|
| Stool reports not made..... | 1 |
| Apparently cured.....       | 8 |
| Remains a carrier.....      | 1 |

It was the writer's impression that individual clinics had had a fairly large experience in the surgery of the typhoid carrier. It was not until last autumn that he learned from Doctor Haaland, of Bergen, Norway, that a large series was not available from any individual clinic, and that our series at the Presbyterian was as large as any as yet reported. Haaland<sup>18</sup> recently reported fourteen cases in the *London Lancet*. It happens that our series comprises the same number. Both his and our results are very similar and

offer more evidence in favor of cholecystectomy than do the statistics of other investigators. Haaland's cases differ from ours in that the majority of his patients showed the paratyphoid bacillus whereas thirteen of our fourteen cases were straight typhoid carriers.

In the Presbyterian series of fourteen cases three were operated upon by Doctor Auchincloss, eleven by the writer. Of these patients, six were operated upon during the late convalescence from typhoid for which they had been treated in the Presbyterian Hospital and where their carrier state had been established. All six were promptly cured of the carrier state. Of the remaining eight cases, three were sent to the writer as carriers—*i.e.*, they were known to be carriers for periods of six months to two years. The remaining five cases all were unaware that they were carriers, and three did not know that they had typhoid, in fact denied it. The two who acknowledged having had the disease gave the time of their typhoid as ten and sixteen years before the date of their operation. In the family of the patient who had had typhoid sixteen years previously the husband had had a very severe typhoid with perforation the year before she came for her operation and stated that the source of her husband's typhoid was difficult to explain as they had been living together that summer away from any possible source of infection.

Of these fourteen carriers, one had contracted her disease from a known carrier. The last patient operated upon by the writer was a woman, seventy-six years of age. She was one of several typhoid cases traced to a typhoid carrier in a missionary home. While she was in the hospital as a convalescent it was proven that she gave the disease to a patient in the ward. Knowing that she had contracted typhoid from a carrier and that she was a carrier herself she willingly consented to a cholecystectomy and now is freed by the Board of Health as a carrier.

Of those patients, two had a cholecystostomy done. One remained a carrier for three years and was then lost to the hospital and Board of Health follow-up. She refused cholecystectomy. Of the twelve cholecystectomized patients two died, but both these patients were deeply jaundiced and were operated upon for long standing gall-stone disease with cholangitis—*i.e.*, the inflammation had progressed beyond the gall-bladder into the duct system. Of the ten surviving cholecystectomies, all were cured of the carrier state except one patient who is still a carrier nine months after his operation. His duodenal bile still shows typhoid bacilli and he has to be classed as a liver carrier.

Comparing Haaland's fourteen cases with our series, he reports thirteen cholecystectomies and one cholecystostomy. One of the cholecystectomies died six days after operation. Of the thirteen survivors, one remains a liver carrier, one a liver and urinary carrier—*i.e.*, eleven of the thirteen have been freed for periods of six months to five and a half years; or, 84.5 per cent. of Haaland's cases were cured. Eighty-three and three-tenth per cent. of our cases are considered cured by surgery.

## SURGICAL TREATMENT OF BILE TYPHOID CARRIERS

In dealing with the typhoid carrier problem we have to consider these points:

1. A convalescent from typhoid fever should have at least one negative duodenal culture and three negative successive stool cultures before being discharged to the community.

2. If his tests show continued presence of bacilli in his duodenal bile he has to be considered a bile carrier. If his bile is negative but his stool positive he belongs to the rare form of intestinal carrier and is not amenable to surgery.

3. If, at the end of three months, the patient still continues to show bacilli in his duodenal contents he must be considered a chronic bile carrier.

4. If there has been any symptom of cholecystitis, or if a cholecystogram shows evidence of abnormal concentration of dye or the presence of gall-stones, the probabilities are very great that the focus is the gall-bladder.

5. The presence of a gall-stone, porous and pervious to typhoid bacilli, prevents the gall-bladder from freeing itself of infection, for it both hinders mechanically the emptying of the gall-bladder and reinfects the fresh, incoming bile.

6. Certainly if the chronically infected gall-bladder, with or without stones, continues to reinfect the liver and bile passages long enough, the probabilities of the individual becoming a duct or liver carrier as well as gall-bladder carrier increase as time goes on. It may be that the sacculi in the wall of the common duct become the seat of infection.

7. To the intelligent and conscientious individual the mental distress and the stigma of being a carrier are very great; and to every carrier the physical and occupational restrictions and the constant surveillance of the health authorities are so irksome as to make every sensible carrier anxious to undertake any measure that offers a good chance of cure. The ignorant or lawless carrier who breaks parole is subject to incarceration, but it is this type that usually refuses surgery and remains a charge and menace to the community.

8. For the chronic bile carrier surgery is the only measure that offers any possibility of a cure. A cholecystectomy gives probably a 70 per cent. chance of cure. If the operation is done while the disease is limited to the gall-bladder the risk of the operation in competent hands is less and the chance of cure greater than if the duct system is involved.

9. If at the time cholecystectomy is done the common duct is drained through the stump of the cystic duct, it can be determined by culturing the common-duct bile whether the ducts are free. If they are infected the continuous free drainage of bile, as pointed out by Garbat, favors the sterilization of the liver and duct system. We believe this is an added factor in insuring a cure of the bile carrier.

10. Inasmuch as the great majority of bile carriers have gall-stones and chronic cholecystitis the operation is not necessarily *pro bono publico*, but may be looked upon as of benefit to the individual as well as to the community.



# ALLEN O. WHIPPLE

| History number | Sex and age | Date of typhoid | Date when recognized as carrier | Widal | Culture of urine | Culture of faeces | Culture of duodenal contents | Operative findings              |   |             |                 | Post-operative findings      |                     |                  |                   | Follow-up Notes  |
|----------------|-------------|-----------------|---------------------------------|-------|------------------|-------------------|------------------------------|---------------------------------|---|-------------|-----------------|------------------------------|---------------------|------------------|-------------------|--|
|                |             |                 |                                 |       |                  |                   |                              | Operation                       | Pathology of gall-bladder                     | Gall-stones | Culture of bile | Culture of gall-bladder wall | Duration of fistula | Culture of urine | Culture of faeces |  |
| 34079          | F 36        | 1907            | 1917                            | +     | 0                | +                 | 0                            | 1917-ostomy. Common duct. Drain | Chronic inflammation                          | C.D.        | +               | 0                            | 16 days             | +                | 0                 | 1, 16, 36, 60, 85 months all negative for B. typhosus. Urine examination 60 months, negative.  |
| 37180          | F 22        | Denied          | 1917                            | 0     | 0                | 0                 | 0                            | 1917-ostomy. Common duct. Drain | Chronic and acute cholecystitis               | +           | +               | +                            | 14 days             | +                | 0                 | Stools became negative on sixteenth day and at the end of one month. Patient then lost to follow-up.   |
| 37525          | M 56        | Denied          | 1924                            | 0     | 0                | 0                 | 0                            | 1924-ostomy                     | Chronic cholecystitis and chronic cholangitis | +           | +               | +                            | 17 days             | +                | C.D. bile         | Died of uræmia and pancreatitis on seventeenth day, shown by autopsy.  |
| 39495          | F 28        | 1918            | 1918                            | +     | +                | +                 | 0                            | 1918-ostomy                     | Acute suppurative cholecystitis               | +           | +               | 0                            | 3 mos.              | +                | 0                 | Remained a carrier for three years and then was lost.  |
| 55540          | F 42        | 1922            | 1922                            | +     | +                | +                 | +                            | 1923-ostomy                     | Chronic cholecystitis                         | +           | +               | +                            | None                | +                | +                 | Had several examinations of the faeces for a period of three months, all negative. Has been seen at interval of twelve, twenty-four, seventy-two months. Is in excellent health. |
| 58469          | F 38        | Denied          | 1923                            | 0     | 0                | 0                 | 0                            | 1923-ostomy                     | Chronic cholecystitis                         | +           | +               | 0                            | None                | 0                | 0                 | Was followed for a period of twenty-four months but stool cultures were not done.  |
| 60090          | F 17        | 1925            | 1925                            | +     | +                | +                 | +                            | 1925-ostomy                     | Chronic cholecystitis                         | +           | +               | +                            | None                | +                | +                 | Board of Health freed the patient after one negative duodenal bucket test and three negative stools. Thirty-three months' follow-up, is in excellent health.                     |
| 65694          | M 53        | 1920            | 1923                            | +     | +                | +                 | +                            | 1925-ostomy                     | Chronic cholecystitis                         | +           | +               | +                            | 6 weeks             | 0                | +                 | One year later an operation for common-duct stricture showed the common-duct bile free from typhoid.   |

## SURGICAL TREATMENT OF BILE TYPHOID CARRIERS

| F 32  | 1911 | 1927                   | 0    | 0 | 0 | 1927-ectomy | Chronic cholecystitis                                | + | +              | + | None | 0 | + | 4 days   | 0 | + | 0 | + | + |
|-------|------|------------------------|------|---|---|-------------|--|---|----------------|---|------|---|---|----------|---|---|---|---|---|
| 69100 |      |                        |      |   |   |             |  |   |                |   |      |   |   |          |   |   |   |   |   |
| 69946 | F 22 | 1925                   | 1925 | + | + | +           | Chronic cholecystitis                                | + | +              | + | None | 1 | + | —        | — | + | — | + | + |
| 69504 | F 35 | 1927                   | 1928 | + | + | +           | Chronic cholecystitis                                | + | +              | + | None | 1 | + | 4 days   | 0 | + | 0 | + | + |
| 70827 | F 57 | para 1926 <sup>2</sup> | 1928 | 0 | 0 | 0           | Chronic cholecystitis, chronic and acute cholangitis | + | Paratyphoid B. | + | None | 0 | + | 10th day | 0 | + | 0 | + | + |
| 71480 | M 48 | 1927                   | 1927 | + | + | +           | Chronic cholecystitis                                | + | +              | + | None | 1 | + | +        | + | + | + | + | + |
| 70404 | F 76 | 1927                   | 1928 | + | + | +           | Chronic cholecystitis                                | + | +              | + | None | 1 | + | —        | — | + | — | + | + |

## DISCUSSION

11. Every carrier operated upon should be followed and if possible two duodenal cultures and three stool cultures, negative for typhoid, should be obtained before declaring the carrier cured. These statistics should be made available for Board of Health authorities so that the uncertainty as to the results of cholecystectomy now so prevalent may be replaced with facts.

From the fact that five of the fourteen cases in the Presbyterian Hospital series were found to be carriers only as a result of routine cultures of the gall-bladder bile and gall-bladder tissue, the point is to be emphasized that bacteriological studies of the bile and gall-bladder tissue from the tissue removed at the time of operation have, in addition to others, the advantages of detecting possible carriers that may subsequently be found to be permanent duct or liver carriers. Such cases, of course, should be reported to the local Departments of Health so that these individuals will not continue to be a menace to the community.

## BIBLIOGRAPHY

- <sup>1</sup> Bureau of Statistics, Metropolitan Life Insurance Co.
- <sup>2</sup> Garbat, H. L.: Typhoid Carriers and Typhoid Immunity, Monograph xvi, Rockefeller Institute, 1922.
- <sup>3</sup> Koch, R.: Sitzung des Wissenschaftlichen Senats bei der Kaiser Wilhelm Akademie, November, 1902.
- <sup>4</sup> Frosch, C.: Festschrift zum Sechzigsten Geburtstage von Robert Koch, p. 691, Jena, 1903.
- <sup>5</sup> Von Drigalski, quoted by S. Endo. *Centralbl. Bakteriöl. Obf. 1. Orig. vol. xxxv*, p. 109, 1904.
- <sup>6</sup> Von Fütterer, Anton: *Münch. Med. Woch.*, vol. xix, p. 315, 1888.
- <sup>7</sup> Longcope, W. T.: See Gay's Monograph on Typhoid Fever, p. 269. The Macmillan Co., 1918.
- <sup>8</sup> Blochstein, O. G.: *Bulletin Johns Hopkins Hospital*, vol. ii, p. 96, 1891.
- <sup>9</sup> Gay, F. P.: Typhoid Fever, p. 115. The Macmillan Co., 1918.
- <sup>10</sup> Pratt, J. H.: *Amer. Jour. Med. Science*, November, 1901.
- <sup>11</sup> Sacquépée, E.: Les porteurs de germes. *Bulletin Inst. Pasteur*, vol. viii, No. 1, p. 49, 1910.
- <sup>12</sup> Ledingham, J. C. G., and Arkwright, J. A.: The Carrier Problem in Infectious Diseases. Longmans, Green and Co., New York, 1912.
- <sup>13</sup> Soper, Major Geo. A.: *The Military Surgeon*, vol. xlv, No. 1, July, 1919.
- <sup>14</sup> Park, William H.: Personal Communication.
- <sup>15</sup> Roberts, B. E.: Personal Communication.
- <sup>16</sup> Dehler: *Münch. Med. Wochenschr.*, Nos. 16 and 43, 1907.
- <sup>17</sup> Fromme, A.: *Deutsch. Zeitschr. f. Chir.*, vol. cvii, p. 578.
- <sup>18</sup> Haaland, M., and Haaland, M.: *The Lancet*, December 3, 1927; also, *Saertryk av Norsk Mag. f. Laegev.*, p. 1057, November-December, 1927.

DISCUSSION: DR. EMMET RIXFORD, of San Francisco, Cal., remarked that it would seem that the obvious thing to do is to make routine bacteriological examination of the gall-bladder or the contents in all cases of cholecystectomy or cholecystostomy, whether there is a history of previous typhoid fever or not. Not very long ago he recovered living typhoid bacilli from the contents of the gall-bladder in a lady of sixty-five years, and subsequently found the bacilli in the stools. The lady was positive she had never had typhoid

## SURGICAL TREATMENT OF BILE TYPHOID CARRIERS

fever. It was several months after the cholecystectomy before the stools were free of typhoid bacilli.

Not long ago there was an epidemic of typhoid fever in San Francisco which was traced to a carrier among the employees of a dairy. The Board of Health ordered that the man be not employed in any food purveyor's establishment, and especially not in any dairy. The labor unions put very great pressure on the Board of Health to have that order rescinded on the ground that the man could not work to advantage except in a dairy and he had a right to earn his living. We had quite a merry fight over the thing.

DR. EDWARD P. RICHARDSON, of Boston, Mass., said that the State Department of Health in Massachusetts, if it finds a typhoid carrier who is also a food handler, attempts to persuade that person either to change his occupation or to be admitted to a hospital for the purpose of operation. The State of Massachusetts has provided a small sum to cover the hospital care of such individuals as are operated on.

The indication for operation when such a carrier is admitted to the hospital, provided the patient is a good operative risk, is a positive culture of the typhoid bacillus on duodenal intubation. At the Massachusetts General Hospital there have been eight such cases operated upon and each one had a pathological condition in the gall-bladder which would justify cholecystectomy.

These cases have recovered from operation and by it have been converted from carrier individuals to those with a negative stool culture.

DR. FRANK S. MATHEWS, of New York City, asked whether all the patients that Doctor Whipple had operated upon who were typhoid carriers also had stones. It had been the speaker's impression that the way the condition is brought about is that in an epidemic of typhoid, those persons who get the disease and already have stones become carriers. Chauffard, in his "Lecons Sur La Lithiase Biliaire" has called attention to the fact that persons who have typhoid do not frequently come to operation for gall-stones within a reasonably short time and hence argues that typhoid does not cause stones. The suggestion, then, is that carriers as a rule become carriers because they have gall-tones rather than develop stones as a result of a typhoid. There seems little evidence that typhoid *per se* is a cause of gall-stones.

DR. ALLEN O. WHIPPLE (in closing the discussion): In regard to the incidence of gall-stones in these patients, twelve of the fourteen cases in his series did have gall-stones, and one or two of them within a period of three months after the disease. He believed undoubtedly that the presence of a porous foreign body in the gall-bladder containing the typhoid bacilli is the chief factor in continuing the typhoid strain in these carriers.

In dealing with the typhoid carrier problem one has to consider these points: First: A convalescent from typhoid fever should have at least one negative duodenal culture and three negative, successive stool cultures before being discharged to the community. If his tests show continued presence of bacilli in his duodenal bile he has to be considered a bile carrier. If his bile is

## DISCUSSION

negative but his stool positive he belongs to the class containing the rare form of intestinal carrier and is then not amenable to surgery.

If at the end of three months the patient still continues to show bacilli in the duodenal contents he should be considered a chronic bile carrier. If there have been any symptoms of cholecystitis, or if the cholecystogram shows no evidence of the dye or the presence of gall-stones, the probabilities are very great that the focus is the gall-bladder. The presence of a gall-stone, porous and pervious to typhoid bacilli, prevents the gall-bladder from freeing itself from infection and the re-infection of the incoming bile.

Certainly if the chronically infected gall-bladder, with or without stones, continues to re-infect the liver and bile passages long enough, the probabilities of the individual becoming a duct or liver carrier, as well as a gall-bladder carrier, increases as time goes on. It may be that the parietal sacculi in the wall of the common duct become the seat of the infection.

To the intelligent and conscientious individual the mental distress and the stigma of being a carrier are very great. To every carrier the physical and occupational restrictions and the constant surveillance of the health authorities are so irksome as to make every sensible carrier anxious to undertake any measure that offers a good chance of cure. The ignorant or lawless carrier who breaks parole is subject to incarceration. This is the type that refuses surgery and remains a menace to the community.

Regarding what Doctor Homans had said in the cases coming to operation, they had found six of these carriers because of the routine culture of the bile and gall-bladder tissue. They would never have known that they were carriers, or potential carriers, but for that. Furthermore, in one of their cases they found that the patient, even after the gall-bladder was removed remained a carrier for a period of some three months. The routine culture, therefore, of bile and gall-bladder tissue is worthwhile whether or not the patient gives a history of typhoid.



## THE FOWLER POSITION AND ITS RELATION TO DILATATION OF THE STOMACH

BY CHARLES L. GIBSON, M.D.

AND

PRESTON A. WADE, M.D. (By Invitation)

OF NEW YORK, N. Y.

THE semirecumbent position, generally known in this country as the Fowler position, was originally introduced as a therapeutic measure in the treatment of acute peritonitis, particularly following appendicitis, and its value seems to have been unquestionable.

After several years of use of it in these conditions I got the impression that we had perhaps relatively more trouble, paresis or even mechanical disturbance of the intestine, after operation and instituted the practice of putting patients in the flat position as soon as improvement was manifest, usually about thirty-six hours post-operative, with apparent benefit.

The Fowler position has gradually been utilized more and more in the treatment of operations in the upper abdomen, particularly the gall-bladder and stomach. The reasons for using it in these conditions vary. I think most operators felt that the patients were more comfortable and were less likely to develop pulmonary manifestations.

It seemed to me, however, as time went on that many of these patients seemed, even after relatively simple operations, to develop more stomach symptoms, particularly those of a dilatation, requiring lavage, postural treatment, etc.

The explanation might be of several kinds; one, perhaps, being the compression of the duodenum by the drag on the superior mesenteric artery by the crowding down of the intestines in the pelvis, especially when the intestines were unduly full of gas. Recently, therefore, we decided to put these patients in the flat position and we have some statistics which seem to show diminution in the amount of post-operative dilatation as judged by the necessity of lavage of these cases.

Meanwhile, we have kept track of the pulmonary complications (bronchitis, pneumonia, massive atelectasis and pulmonary embolism) and we are gratified to note that there has been only a 2 per cent. increase in the pulmonary manifestations.

Perhaps more convincing in my personal experience is a small but important series of private cases, most of them of considerable severity—resection of the stomach, cholecystectomy, etc.—in which the stomach tube has now been discarded for a year and a half and without any noteworthy pulmonary complications at any time.

This paper, therefore, is offered as a possible hint in the direction of post-operative treatment.

# GIBSON AND WADE

An analysis of 249 cases has been made by Dr. Preston A. Wade, assistant surgeon, and a comparison of the two periods has been made—the Fowler position being figured from January 1, 1927, to March 1, 1928, and the flat position from March 1, 1928, to May 1, 1929.

It will be noted that the greatest benefit seems to be in the various operations on the gall-bladder in which the post-operative stomach manifestations (dilatation) have been reduced from 43 per cent. to 20 per cent.

## ANALYSIS OF 249 CASES

Fowler position—141

Flat position—108

|   | Number of cases<br>lavaged | Per cent. |
|---|----------------------------|-----------|
| <i>Chronic cholecystitis:</i>                 |                            |           |
| Fowler position—26 .....                      | 9                          | 34        |
| Flat position—31 .....                        | 5                          | 16        |
| <i>Cholelithiasis:</i>                        |                            |           |
| Fowler position—39 .....                      | 19                         | 48        |
| Flat position—3 .....                         | 0                          | 0         |
| <i>Acute cholecystitis:</i>                   |                            |           |
| Fowler position—8 .....                       | 4                          | 50        |
| Flat position—10 .....                        | 4                          | 40        |
| <i>Ulcer of stomach:</i>                      |                            |           |
| Fowler position—12 .....                      | 5                          | 41        |
| Flat position—4 .....                         | 1                          | 25        |
| <i>Perforating ulcer stomach:</i>             |                            |           |
| Fowler position—6 .....                       | 2                          | 33½       |
| Flat position—8 .....                         | 2                          | 25        |
| <i>Ulcer of duodenum:</i>                     |                            |           |
| Fowler position—19 .....                      | 11                         | 58        |
| Flat position—29 .....                        | 9                          | 31        |
| <i>Perforating ulcer duodenum:</i>            |                            |           |
| Fowler position—15 .....                      | 1                          | 6         |
| Flat position—11 .....                        | 1                          | 9         |
| <i>Carcinoma of stomach and gall-bladder:</i> |                            |           |
| Fowler position—16 .....                      | 5                          | 34        |
| Flat position—12 .....                        | 2                          | 16        |
| <i>Total gall-bladder cases:</i>              |                            |           |
| Fowler position—73 .....                      | 32                         | 43        |
| Flat position—44 .....                        | 9                          | 20        |
| <i>Total stomach and duodenal cases:</i>      |                            |           |
| Fowler position—68 .....                      | 24                         | 35        |
| Flat position—64 .....                        | 15                         | 25        |
| <i>All cases:</i>                             |                            |           |
| Fowler position—141 .....                     | 56                         | 39        |
| Flat position—108 .....                       | 24                         | 22        |

## THE REMOVAL OF WIDE SCARS AND LARGE DISFIGUREMENTS OF THE SKIN BY GRADUAL PARTIAL EXCISION WITH CLOSURE

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THE question of removing a wide scar or a large disfigurement of the skin, without leaving a result which is as objectionable as the original trouble, has always been a difficult problem in plastic surgery, and the object of this paper is to call your attention to a simple method by which this may be accomplished.

It should be understood that the disfigurements considered here are of benign character only, as it would be disastrous to attempt the removal of malignant skin lesions by gradual partial excision.

As far as I can ascertain, the first communication on the subject was by H. Morestin, who in June, 1915, read a paper before the Society of Surgery of Paris "*La réduction graduelle des difformités tégumentaires.*" It was my good fortune to see this report soon after the publication of the Bulletin of the Society and I immediately realized the great importance of the contribution and utilized it at once.

It was only necessary to try the method to become convinced of its value, and I have since then used gradual partial excision with satisfaction on a great many cases. The method has also been taught to students in my division for years.

Sistrunk reported "A Method of Removing Scars in Stages" in 1926, being unaware of earlier work along the same lines. Strange as it may seem little general notice has been taken of this important plastic principle.

Gradual partial excision is the progressive reduction in size of a disfigurement by successive excisions, which are repeated at variable intervals. The method depends for its success upon the fact that the normal skin has a tremendous capacity to stretch, especially when the stretching is done slowly.

It may be asked why should multiple operations be undertaken when the disfigurement might be removed at a single operation and the resulting defect be covered by a skin graft or by the shifting of a pedunculated flap. The answer to this question is that the procedure is simpler and the ultimate result, in suitable cases, is very much better. It may also be asked why radium or X-ray could not be used to obliterate some of the disfigurements, such as hæmangiomas. The answer is, that radiation had already been tried unsuccessfully in a number of the cases subsequently relieved by gradual partial excision and, unfortunately, in some instances the original condition was complicated by ray burns.

Morestin reported several cases, among them the removal of an extensive pigmented mole on the face of a child. He operated on this patient twelve times in a little over four months. Another case, a burn scar of the neck and



A



B



C



D

FIG. 1.—X-ray burn following multiple treatments for glands of the neck. Illustrating the first step of gradual partial excision with closure. A, Shows typical changes caused by X-rays; keratosis, frequent ulceration, atrophy, telangiectasis, pain and stiffness. B, Shows the ellipse of tissue removed, fifteen centimetres long by five centimetres at the widest part. C, Shows the wound one week after operation. Note type of closure. D, Result after four weeks. Note that the most objectionable portion of the tissue has been removed. The scar is narrow and healing has been satisfactory.

## THE REMOVAL OF WIDE SCARS



A

B



C



D

FIG. 2.—The removal of a burn scar of many years' duration by gradual partial excision with closure. A, Note the size and location of the scar on the neck and upper chest wall. B, The result of the first excision after eight months. Note the narrowing of the scar. C, Result of the second operation after nine months. The scar is much narrowed and the surrounding skin has stretched so that there is no tension. D, Result of the third excision with closure. Photograph taken sixteen days after the operation. The original scar has been practically entirely removed. The result will be a line scar and if this tends to spread in places, it may be narrowed, otherwise nothing further may be necessary. There is no limitation of neck movement, and the skin has stretched to meet the demand placed upon it.





A



B



C

FIG. 3.—Tattoo marks on the forearm. Removal by gradual partial excision with closure. A, Actual size of the design. B, Five weeks after the first ellipse of tissue was removed. Note the narrowing of the pigmented area and the type of scar. C, Result of second step in the removal. Note the small area of the design which remains.

## THE REMOVAL OF WIDE SCARS

breast, was operated on eighteen times in eleven months. In my series the number of operations necessary to accomplish the desired result has varied between two to twenty, depending on the size and character of the disfigurement.

*Method.*—The part may be prepared in any way selected by the surgeon, but when dealing with scar infiltrated tissue, soap and water followed by alcohol and ether usually cause less subsequent irritation than when stronger chemical antiseptics are employed.

When the area to be excised is small, there is no necessity for the patient being hospitalized, but where the areas are larger, hospitalization is advisable. Local anæsthesia may often be used, preferably by nerve or regional block, as infiltration distorts the tissues, makes the closure more difficult, and may interfere with healing, especially when dealing with scars. If the disfigurement is on the face or neck, and general anæsthesia is required, ether by the colonic route is the method of choice; otherwise gas and oxygen, or ethylene may be used.

*Technic.*—After determining the amount of tissue to be excised from the disfigurement, outline it with 5 per cent. brilliant green in alcohol before the anæsthesia is given, as in this way we eliminate any question as to the size, shape and situation of the area to be removed, after the patient is draped. The pattern is usually made in the shape of an elongated ellipse whose long axis, in order to facilitate closure, is in the most advantageous direction, but any shaped area may be removed as long as the resulting defect may be closed by suture.

The marked out portion should be cleanly excised with a sharp scalpel down to normal tissue, care being taken to avoid unnecessary injury to the edges which are to be approximated. All hæmorrhage should be checked. Then the edges are approximated with a few catgut or fine waxed silk sutures in the subcutaneous tissue and on-end mattress sutures of horse hair or waxed silk in the skin. The disfigurement is thus reduced in size by the amount of tissue removed. On the sutured wound place one thickness of gauze impregnated with 3 per cent. xeroform ointment, or several layers of silver foil with its porous paper, and over this a sterile sea sponge applied under even pressure and snugly secured with adhesive plaster and bandage.

In many instances, on account of the character of the tissue dealt with, it is impossible to make the closures following the primary and intervening operations as accurate as might be desired, but every effort should be made to have the final closure as perfect as possible. After an interval, the length of which varies according to the situation, and when the surrounding skin has stretched sufficiently, more of the disfigurement is excised in the same way, the selection of the portion to be removed depending on conditions. This procedure is continued at suitable intervals until the disfigurement has been completely removed and a narrow scar remains.

The successive excisions should ordinarily be made inside the area of the scar or disfigurement until the final step is reached, when it may be necessary to encroach slightly on the surrounding tissue. By proceeding in this way the

resulting narrow scar will be little if any longer than the long axis of the disfigurement. Should the excisions extend into the normal skin beyond the margins of the disfigurement then naturally the resulting scar will be longer.

*Remarks.*—The technic is simple and these operations are seldom attended by any danger. In the process of gradual partial excision, there is no contra-indication to cutting through large pigmented naevi, extensive hairy moles, cavernous angiomas, or keloids.

It is advantageous when dealing with scars to gain everything possible before both the primary and the secondary operations by preliminary massage and motion, thus loosening and softening the scar and mobilizing the surrounding skin.

The amount which it is safe to excise varies with the elasticity of the skin around the disfigurement and the determination of this point is sometimes a nice one, as it is essential in carrying out the procedure that the wound be immediately sutured and that perprimam healing follow. Occasionally one miscalculates and removes too large an area of tissue and if the defect left by this removal cannot be closed by sutures even under considerable tension, then it becomes necessary to undercut before closure is possible. Ordinarily, I prefer not to undercut as undercutting tends to make more scar, and the tissues do not loosen as readily for the secondary operations.

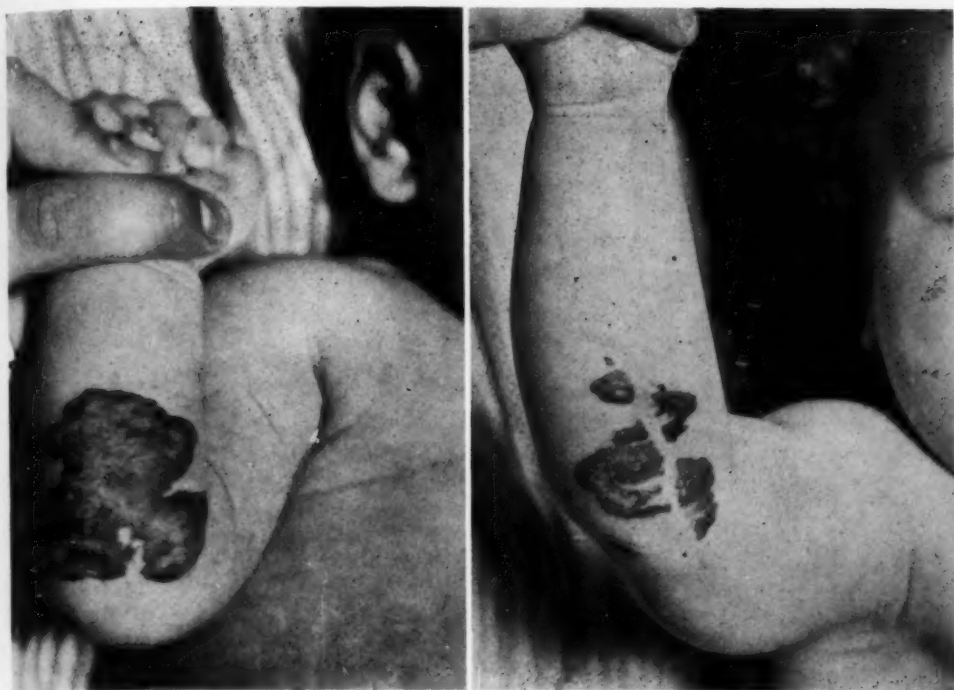
In some of his cases, Morestin operated a second time within three or four days, and where the skin surrounding the growth is normal and quite lax this may be permissible. However, I have found it advisable in the majority of cases to let a considerable period of time elapse between operations, and in my experience this is essential especially where the maximum single excision has been done, and also particularly where the tissues are scar infiltrated. Where small areas have been removed the skin may stretch sufficiently in a week or two, but I have frequently allowed six months or more to elapse between operations.

It is difficult to appreciate the possible extent of gradual stretching of the surrounding skin and its adaptability, unless one is conversant with this procedure. Scars and disfigurements on the nose, eyelids and other parts of the face must be handled with great care, as considerable deformity may follow injudicious excisions. When dealing with angiomas, I have found it useful to surround the growth with a thick lead wire which is pressed firmly into the tissues by an assistant, until the excision is done and the wound is closed. In this way bleeding, which otherwise may be severe, is minimized.

When gradual partial excision is used in removing a keloid, the excision is done entirely in the growth itself, all sutures being placed so that they pass through the keloid tissue. Exactly the same process is repeated from time to time as the skin stretches. The final result will be a narrow flat scar instead of the prominent thickened growth. Suitable preliminary X-ray treatment is used on keloids before excision is undertaken.

When dealing with a large scar, say on the neck, it will often be found that there is tissue which can be easily removed in different portions of the scar, and in such a case it is advisable to excise the several smaller areas rather than

# THE REMOVAL OF WIDE SCARS



A

B



C

FIG. 4.—Hemangioma of the forearm involving the skin and subcutaneous tissue. Treatment: gradual partial excision with closure. A, Before operation. Note the size, shape and situation of the growth. B, Result six months after the excision of the first ellipse of tissue. Note the scar and the diminution in size of the angioma. C, Three months after the second excision. Comparatively little of the growth is left. All of the subcutaneous involvement has been removed, and the superficial portion which remains can be easily removed, either by excision or by carbon dioxide snow. Note the longitudinal scar and compare this stage with the original condition.

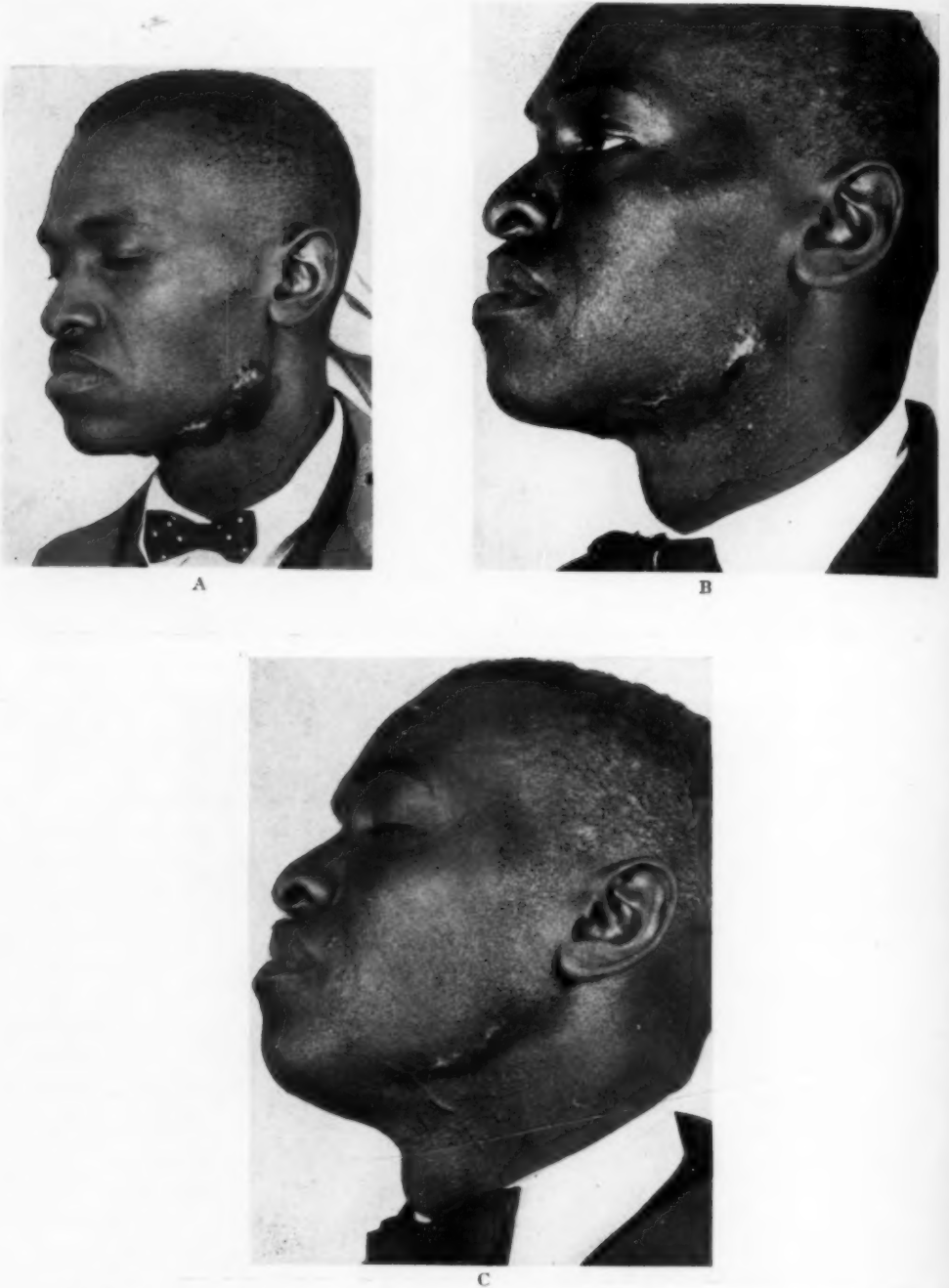


FIG. 5.—Illustrating the treatment of keloid by gradual partial excision. A, Shows the keloid before preliminary X-ray treatment was given and gradual partial excision was commenced. B, The growth was removed in several stages over the period of a year and the photograph shows the final result. C, Shows the same area four years later. This indicates the permanence of the results obtained by this method.



## THE REMOVAL OF WIDE SCARS

to attempt the removal of a single larger piece. The sutured wounds in such a case may run in several directions. The removal of a scar with more or less infiltration of the surrounding skin is much more difficult than when it is surrounded by normal skin, as scar infiltrated skin does not stretch nearly as much as does normal skin. However, such scars can gradually be reduced in size by gradual excision of suitable areas and in many instances excellent results may be obtained.

The procedure takes time and cannot be done in a hurry. It requires considerable patience from both surgeon and patient, but in the great majority of cases, the improvement which soon becomes evident is sufficient to stimulate further mutual effort.

In most instances, if carried out properly, gradual partial excision will remove the disfigurement and frequently the result will be a narrow scar, which may be either straight, or curved, or angled, depending on the way in which the excisions have had to be made. Often it can be managed so that the final scar will lie in a natural fold. Occasionally, it is impossible to completely eliminate a deformity by this method, but the size of the defect may in this way be reduced sufficiently to make a simple plastic procedure possible where the original condition would have necessitated a large mutilating operation, and this in itself is well worth while.

I have used gradual partial excision with closure successfully in removing extensive scars, large pigmented moles, pigmented naevi, hæmangiomata, lymphangiomata, tattoo marks, X-ray and radium burns, localized scleroderma, keloids, etc., and have found that by this procedure these cutaneous disfigurements may be eliminated without mutilation, and that better results may be obtained than by any other method with which I am familiar.

### BIBLIOGRAPHY

- Davis, J. S.: *Plastic Surgery*, pp. 211, 221, 225, 226, 228, 231, 435, 612, 620, 1919.  
Morestin, H.: *La réduction graduelle des difformités tégumentaires*. Bull. et mém. de la Soc. de Chir. de Paris, vol. xli, p. 1233, June 16, 1915, Cicatrice très étendue du crâne réduite par des excisions successives. Bull. et mém. de la Soc. de Chir. de Paris, vol. xlii, p. 2052, September 13, 1916.  
Sistrunk, W. E.: *Plastic Surgery: Removal of Scars by Stages*. Trans. Am. Surg. Assn., vol. xlv, p. 475, 1926.

**DISCUSSION:** DR. WALLACE I. TERRY, of San Francisco, Cal., asked Doctor Davis if the X-ray burns are ultimately taken care of. He had treated according to his method, a young woman who had been X-rayed for goitre. He had removed all of the original scar but the discoloration and the dilated veins remain. Will they disappear afterward?

DOCTOR DAVIS replied that they do not disappear unless they are taken out. Where there is a widespread X-ray burn with varying degrees of skin change, that portion in which there is keratosis and ulceration should be removed with a wide margin. The less immediately important areas such as those showing telangiectatic changes being left, to be excised subsequently if necessary.

TRAUMATIC RUPTURE AS A SEQUENCE TO CONGENITAL  
HERNIA OF THE DIAPHRAGM, WITH AN EXPERI-  
MENTAL STUDY OF ITS MECHANISM AND  
THE EFFECTS OF PHRENICOTOMY

BY PHILEMON E. TRUESDALE, M.D.

OF FALL RIVER, MASS.

ANY abnormality which interferes with the vital functions of respiration, circulation, and digestion warrants the utmost reflection. Therefore, it is my hope that this report which embraces the results of further observation and study of the diaphragm, disabled by hernia or phrenic nerve paralysis,

may be of practical interest. The sphere of thought and action in surgery is replete with entangled and intricate problems, but few are more perplexing than those associated with a breach in so important a structure as the diaphragm.

A review of the literature reveals the element of surprise frequently attending the discovery of diaphragmatic hernia. Escaping in the physical examination it is disclosed by the Röntgen-ray, during operation, or at autopsy. The clinical pre-operative diagnosis, however, is of great impor-



FIG. 1.—Case No. 17609—A. C. Harelip.

tance, especially when acute intestinal obstruction supervenes. The recognition of diaphragmatic hernia on physical examination will be made more often when physicians are on the alert for its weird manifestations. This is borne out by the fact that in one small hospital, the Goddard, at Brockton, Mass., two cases have been discovered, the first at operation, the second on physical examination. The transposition of organs, abdominal and thoracic, must be recognized by the examiner, for this is the key to the diagnosis.

Furthermore, the existence of congenital heart disease or enlarged thymus as a cause of cyanosis and dyspnoea in the new-born should not be considered

## CONGENITAL HERNIA AND RUPTURE OF DIAPHRAGM

final until the presence of diaphragmatic hernia, or eventration of the diaphragm has been ruled out. Acidosis, dysphagia, pyloric obstruction, vomiting, constipation, dehydration, cough, and cataleptiform seizures are symptoms of hernia of the diaphragm in infancy and childhood. Their importance in this relationship may be overlooked, not because diaphragmatic hernia is rare but because it is rarely in the mind of the examiner.

The following case resembled whooping cough, for which the patient was treated until a differential diagnosis was accurately made by Dr. P. H. Leavitt, of Brockton, Massachusetts. This case was of further material importance in demonstrating the occurrence of a major tear through the entire diameter of the diaphragm from the margin of a congenital hernia.

Since I have been unable to find the report of a similar observation in literature, I present our findings in this case with some trepidation. The evidence, however, appears to be determinate. The presence of harelip (Fig. 1), the continuity of pleura and peritoneum over an elliptical area close to the œsophagus,

and a tear extending from this point to the periphery of the diaphragm provides a collection of facts, any other interpretation of which would be difficult. The most plausible explanation would seem to be that a sliding hernia of the stomach filled at the moment with food or gas was suddenly and violently forced through the aperture. Something had to yield and the structure least capable of resisting was the diaphragm, the rent in which stopped only at its perimeter. From the length of the tear, which gave rise to an expanded open area, one might be led to suppose that the immediate transposition of abdomi-



FIG. 2.—Congenital hernia of the left diaphragm converted into complete rupture by external violence.

nal viscera would collapse the left lung, displace the heart, and cause death from asphyxia. Later in this paper I shall present experimental evidence

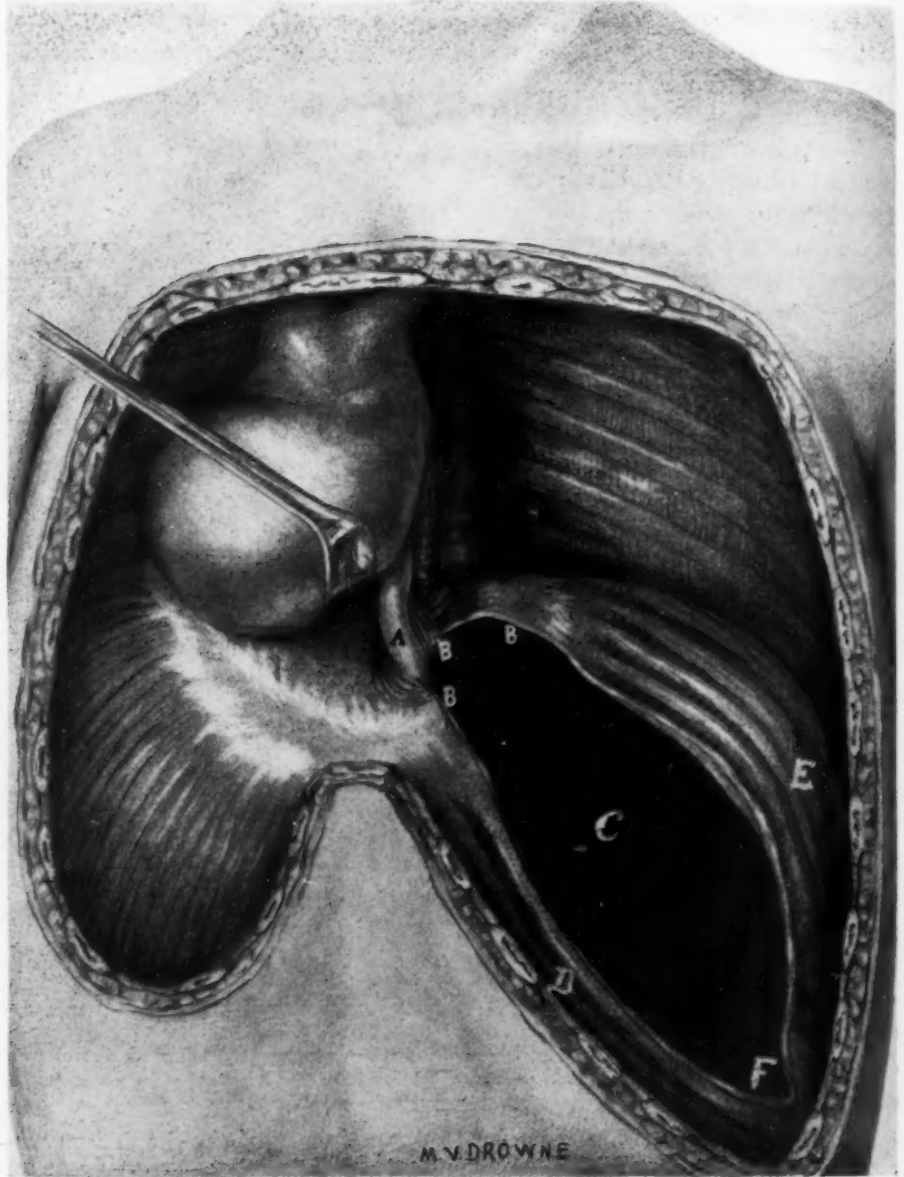


FIG. 3.—Complete rupture of the left diaphragm. Evidence of a preëxisting congenital hernia was observed in the œsophageal region. The tear extended outward from the margin of the congenital opening to the perimeter of the diaphragm. A, Œsophagus; B, area of congenital defect; C, area of traumatic rupture; D, anterior leaf; E, posterior leaf; F, outer angle of tear.

showing clearly that the transposition of organs even in the presence of a very large opening in the diaphragm is not rapid but so gradual that it allows for a compensatory mechanism sufficient to sustain life.

## CONGENITAL HERNIA AND RUPTURE OF DIAPHRAGM

CASE REPORT.—A. C., girl, five years of age, was struck by an automobile March 29, 1928, receiving injuries to her body and right leg. At the Goddard Hospital, Brock-

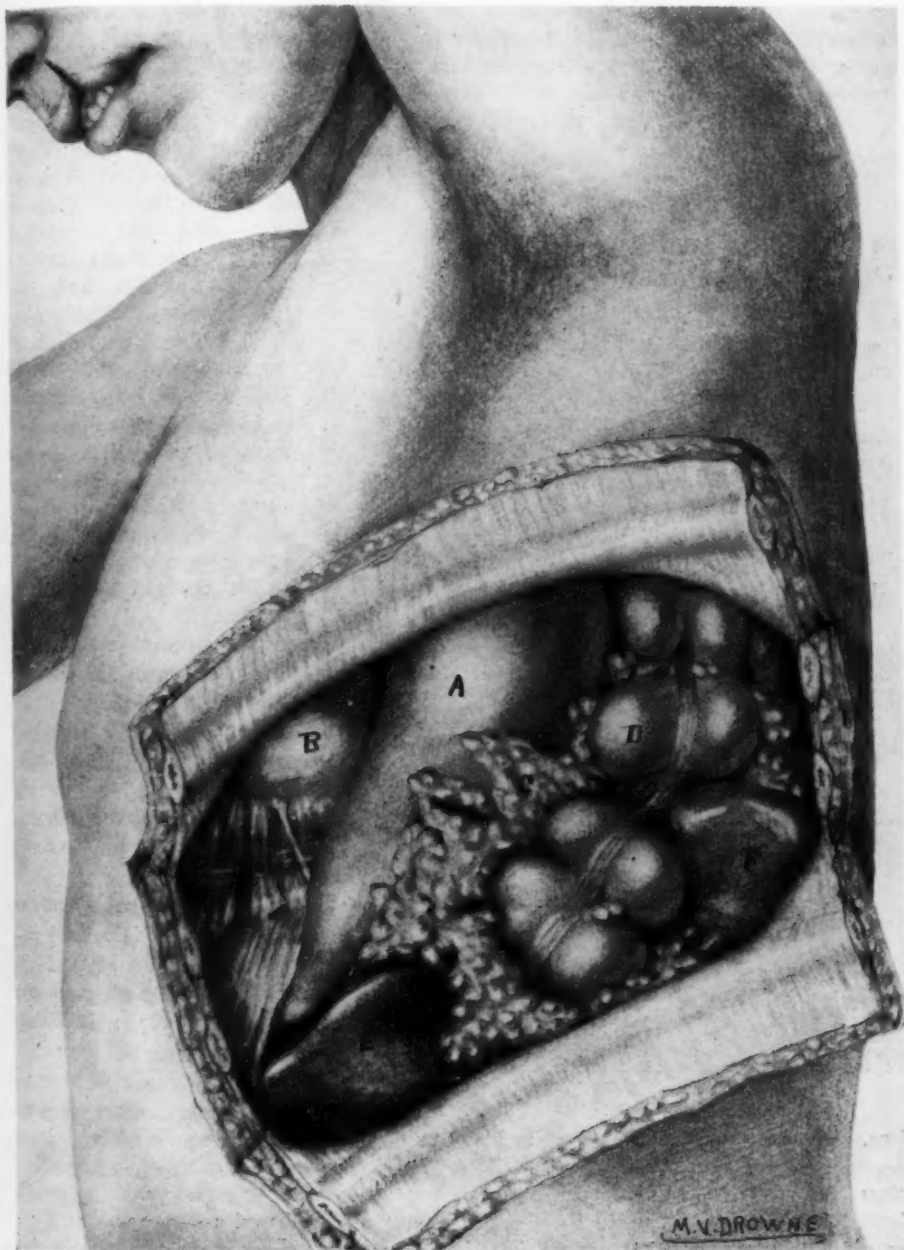


FIG. 4.—Exposing the field of operation through a trapdoor incision in the thoracic wall. The ribs are not removed. Structures to be seen are the stomach, small intestine, colon, omentum, pericardium, left lobe of the liver and the spleen. A, Stomach; B, heart; C, omentum; D, colon; E, liver; F, spleen.

ton, Massachusetts, it was determined that the little patient had a fracture of the right femur. This was treated by the use of traction and later the application of a plaster



case. During her stay in the hospital she developed a peculiar cough, so closely simulating whooping cough that she was treated for it over a period of several weeks. Dr. P. H. Leavitt, suspecting the possibility of a diaphragmatic hernia from the persistence of cough and a dextrocardia, ordered a Röntgen-ray examination of the abdomen after a barium enema. This revealed a loop of the transverse colon extending well up into the left pleural cavity. She was kept under observation and placed on medical treatment for a few weeks during which time her general condition improved materially.

May 13 she was referred to our clinic. On admission her temperature was 100.8°

and her pulse 140. There were the usual symptoms of emotional cyanosis, dyspnea, rapid pulse, rapid respiration, cough, precordial distress, sunken abdomen, and distended chest. Litten's sign could not be observed because the child could not lie down without becoming cyanotic. In observing a paroxysm of coughing we noticed that it lacked the characteristic inspiratory "whoop" of pertussis. Cyanosis and dyspnea were more marked when the patient assumed the recumbent position.

On physical examination the first feature to attract attention was harelip. The concomitant appearance of harelip and diaphragmatic hernia prompted a minute examination of the texture of the diaphragm in the region of the aperture.

A Röntgen-ray examination after a barium meal revealed the entire stomach in the left thoracic cage. Small scattered shadows indicated the transposition of the small intestine. (Fig. 2.) May 19 a preliminary cecostomy was



FIG. 3.—After operation.

done. There was difficulty in locating the cæcum because it had been drawn upward toward the diaphragm. Improvement followed and the major step of repair was undertaken May 26. Gas oxygen ether anaesthesia was employed. By means of an approach through a trapdoor-opening in the thoracic wall the left pleural cavity was found to contain the entire stomach, the small intestine, the transverse colon, the left lobe of the liver, the spleen, and the omentum. (Fig. 4.) There was no constricted point of transit, nor could either margin of the torn diaphragm be defined. At this point it was thought that there was a congenital absence of the diaphragm, yet the displaced abdominal viscera were reduced without difficulty. The left lung was then found to be collapsed. Close inspection revealed anteriorly a shelf of diaphragm varying along its course from two to six centimeters in width, the narrow portion being about midway, the broadest internally

## CONGENITAL HERNIA AND RUPTURE OF DIAPHRAGM

where it merged into a cup-shaped fold of serous membrane. Further search resulted in finding the remainder of the diaphragmatic leaf in folds along the posterior wall of the thorax. Fig. 3.) Believing that it would expedite matters we began the application of sutures in the region of the œsophagus first, where closure of the aperture, technically, would be more time-consuming. On account of the difficulties met at this point the constant intrusion of hollow viscera at the outer angle of the split diaphragm, and a failing heart beat readily discernible in the foreground, a shift in method of closure was adopted. Using No. 3 chromic catgut, a running suture was started at the outer angle of the tear. This was continued to a point where all gauze packing could be removed without fear of exposing further the upper abdominal contents. After a brief pause the patient's heart action improved. Closure of the more delicate œsophageal end of the opening was then accomplished. Finally, a running suture of fine silk was employed to reinforce the chromic catgut throughout its length. The opening in the thoracic wall was then closed.

During that period of the operation when there was anxiety over the failing heart action, traction was made on the central attachments of the diaphragm and upon the fibers attaching the pericardium to the diaphragm. The object to be achieved by pulling on any portion of the displaced mediastinum was to permit a greater quantity of air to enter the right lung, already considerably limited in its area of expansion. While improvement in the patient's condition followed, there still

remains some doubt as to the agency which brought it about. However, in our experiments upon dogs without use of the mechanical respirator we found that traction on the displaced mediastinum improved the condition of the animal.

Convalescence of the child was marked by a wide range of temperature and pulse. May 30 about 300 cubic centimeters of turbid fluid was aspirated from the left pleural cavity. June 2 the pleuritic effusion had become purulent, and a rubber tube was inserted

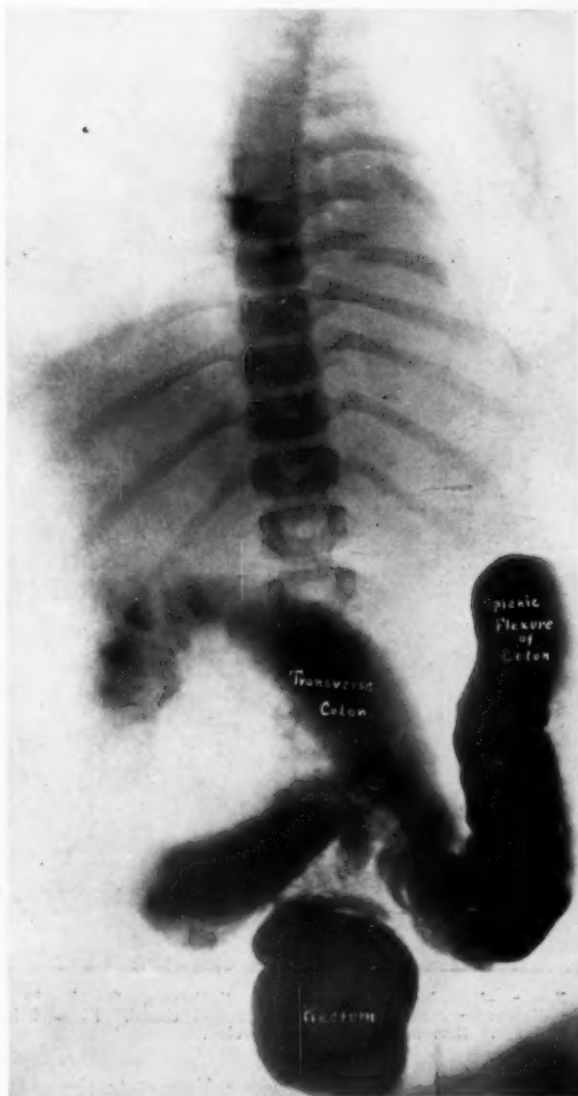


FIG. 6.—After operation.

for better drainage. This was removed June 4. June 8 the outer angle of the wound was opened and another rubber tube was inserted. The exudate gradually subsided permitting removal of the rubber tubes June 16. July 19 an operation was done for repair of the harelip. Her recovery was satisfactory. August 2, X-ray examination after a barium meal demonstrated the presence of the stomach and large intestine in the abdomen, the left diaphragm apparently intact. (Figs. 5 and 6.)

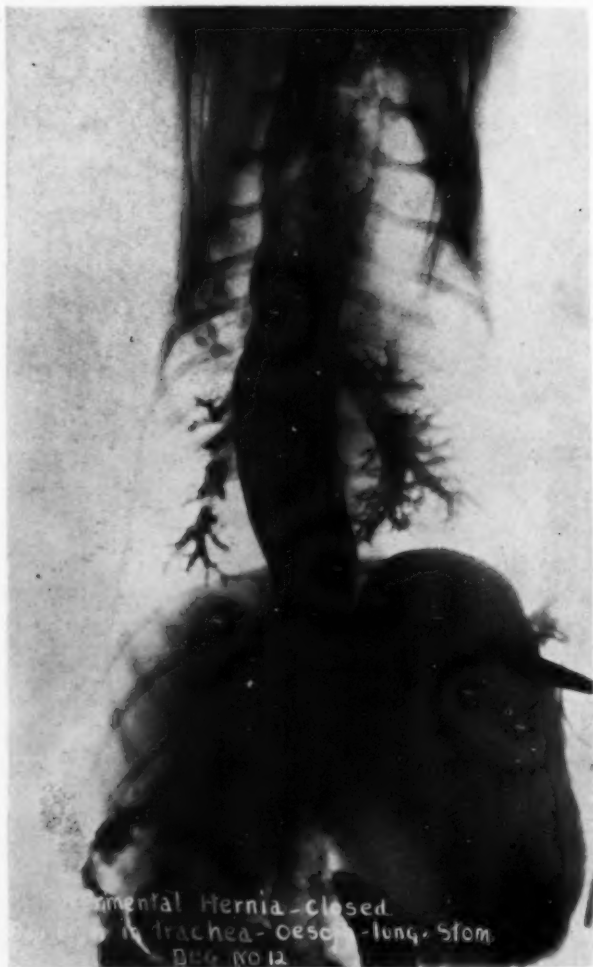


FIG. 7.—Experimental hernia of left diaphragm. Opening in the diaphragm closed. Thoracotomy wound closed. Lipiodol in both lungs. Barium in stomach and colon.

The field of inquiry involved in this case includes: first, the significance of harelip associated with hernia of the diaphragm caused by external violence; second, the size of the tear extending completely across the leaf of the diaphragm; third, the mechanism by which the hernia was produced; fourth, the advantages of a direct transthoracic approach; fifth, the advantage of the two-stage operation during convalescence where a acute intestinal obstruction was not a factor, and sixth, the somewhat surprising ability of the suture line to hold in the presence of an acute suppurative pleuritis. Perhaps the most important among these considerations is the mechanism by which this hernia developed.

The appearance of the tissues adjacent to the oesophagus furnished conclusive evidence that a congenital hernia had existed prior to the accident, upon the hypothesis that the aperture admitted the cardiac portion of the stomach into an area above the diaphragm; that a blow from one part of the automobile severe enough to fracture the femur was probably of sufficient force from another part of the car to produce a sudden violent pressure upon a stomach partly herniated and probably distended. Under such circumstances it is easy to conceive that the degree of pressure at the periph-

## CONGENITAL HERNIA AND RUPTURE OF DIAPHRAGM

ery of the existing aperture was more than it was capable of withstanding. So the diaphragm yielded at the point of least resistance. The dimensions of the tear extending to the perimeter of the diaphragm would appear to confirm this theory. If such were the fact and there followed an immediate expulsion of the hollow viscera of the abdomen into the thoracic cavity with collapse of the left lung and displacement of the heart, why did this child not die suddenly? How did she come to survive the shock?

With a view to finding an answer to this question a study of the mechanism of diaphragmatic hernia was conducted in the Laboratory of Surgical Research at the Harvard Medical School. Through the courtesy of Dr. Harvey Cushing and the assistance of the Röntgenological Service at the Peter Bent Brigham Hospital, experiments were carried out upon sixteen dogs and one monkey. The object of the investigation was to study under direct observation the motion of those organs involved in hernia of the diaphragm during the process of its

development. Briefly, the plan consisted of making an artificial opening in the diaphragm, closing it again with a running suture each end of which passed through the abdominal or thoracic wall. The abdominal incision or thoracotomy wound was then closed. The animal was placed on a fluoroscopic table, given a barium meal and a barium enema. The running suture in the experimental opening in the diaphragm was then withdrawn. This allowed



FIG. 8.—Experimental hernia of left diaphragm. Barium in both lungs. Barium in the stomach which is in process of transposition. First stage.

the margins of the aperture to flare open. The movements of the stomach and colon were then observed. This experiment was rendered faulty by the existence of a pneumothorax necessarily following the incision in the diaphragm.



FIG. 9.—Experimental hernia of left diaphragm. Barium in both lungs. Intrusion of stomach into the pleural cavity. Second stage.

left lung during operation. Closure of the thoracotomy wound was completed while the lung was in a state of complete expansion. One of the dogs regurgitated the barium meal and inhaled a quantity of it. This produced a surprisingly clear shadow of the bronchial tree in each lung. (Figs. 7 and 8.) Although he survived only an hour observations were made under the fluoroscope and recorded at intervals on X-ray films. The following observations were made from the experimental operation:

The monkey and the first two dogs died from asphyxia soon after the withdrawal of the running suture. It was soon found that an animal with a swinging mediastinum or no vertical partition at all succumbed from asphyxia soon after air was permitted to enter the pleural cavity. However, dog No. 3, singularly, survived a sufficient length of time to permit fluoroscopic study of the stomach and colon through the artificial opening in the diaphragm. Attempts to repeat the experiment on other dogs met with failure until we began to use the mechanical respirator of Erlanger. This resulted in a distinct advance toward an ideal setting. We changed from the abdominal approach to the thoracic, thus providing accessibility for making a longer incision through the diaphragm. In addition it permitted control of the desired degree of expansion of the



CONGENITAL HERNIA AND RUPTURE OF DIAPHRAGM

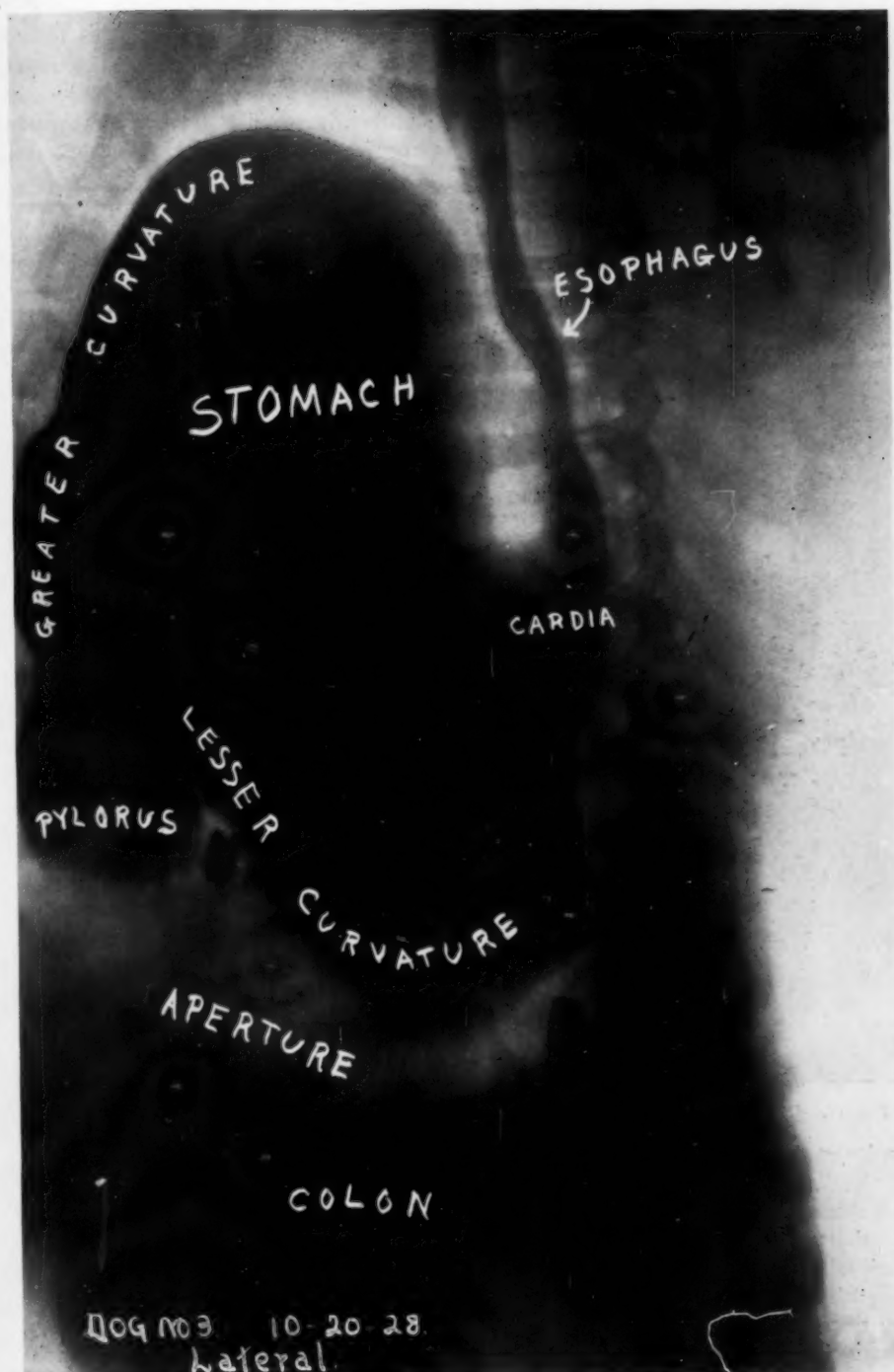


FIG. 10.—Experimental hernia of left diaphragm. Intrusion of stomach into the pleural cavity. Final stage. Lateral view.

Immediately after the removal of the controlling suture in the diaphragm the heart moved toward the opposite side. Contraction of the right leaf of the diaphragm during inspiration increased the intra-abdominal pressure and helped force the loosely attached abdominal organs upward. Thus, the stomach made progress in its ascent only during inspiration. The cardiac portion with its greater curvature uppermost entered slowly, changing its position very gradually with each contraction of the right diaphragm. The left leaf of the diaphragm remained almost motionless held by the

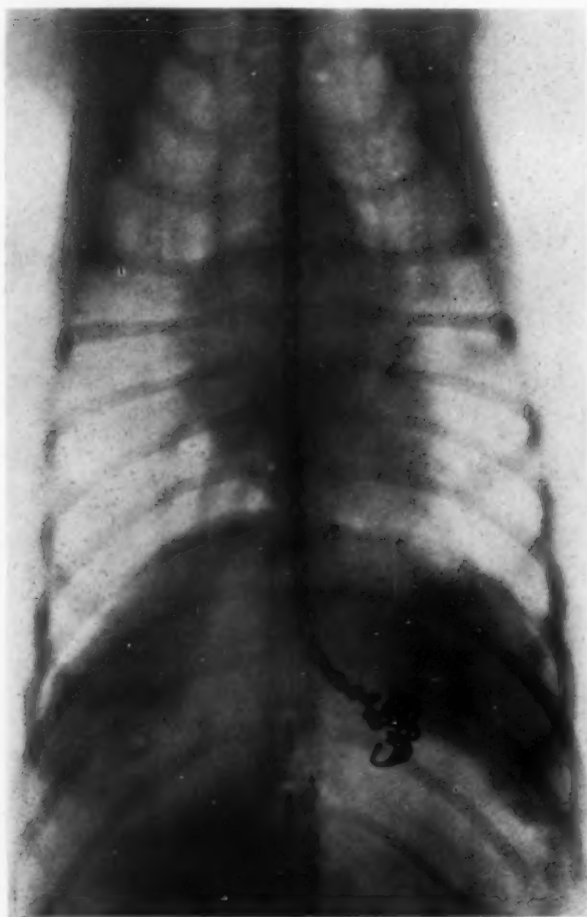


FIG. 11.—Esophagus in normal position. Diaphragm normal.

advancing stomach and partially paralyzed from severed branches of the phrenic nerve. The larger the amount of barium in the stomach the more its upward displacement was impeded. As the stomach continued its rise above the diaphragm (Fig. 8), the greater curvature remained uppermost.

The transverse colon was sharply angulated and followed the stomach through the diaphragmatic opening. The left lung was gradually elevated by the advancing stomach until the bronchi which could be seen were on a horizontal plane. (Fig. 9.) In the final stage the right lung was partially expanding in a cage of reduced dimensions, the major portion of the heart was to the right of the spinal column, the trachea was deflected to the right and the œsophagus arched toward the right by virtue of pressure from the left side on its mediastinal portion and traction on its lower end by the cardiac end of the stomach. The stomach occupied the major portion of the left pleural cavity assuming

an inverted position, while the pylorus took an anterior position approaching the level of the diaphragm. (Fig. 10.) The colon was curved upon itself to the outer side of the stomach. Post-mortem examination revealed the left lobe of the liver dipping into the thorax. The omentum followed the colon and loops of small bowel were found at various points above and below the diaphragm. If the opening were too small for the stomach to enter, the omentum would pass through and take with it a portion of the transverse colon. Therefore, the inference seemed plausible that, in the large openings, obstruction would develop only as a result of torsion either of the stomach on its œsophageal attachment or of the intestine from volvulus; the smaller the opening the greater the liability of obstruction of the large intestine from direct impingement of the margins of the aperture upon the lumen of the gut.

## CONGENITAL HERNIA AND RUPTURE OF DIAPHRAGM

### OBSERVATIONS ON EXPERIMENTAL PHRENICOTOMY

From the appearance of the diaphragm following injury to some of the terminal branches of the phrenic nerve we were led to make a study of the mechanism of the diaphragm following phrenicotomy and its bearing upon that phenomenon, eventration, which has always been classified as a clinical vagary. Our labor was rewarded by disclosing information of practical importance. Instead of approaching the phrenic nerve through an incision above the clavicle and cutting it as it crosses the scalenus anticus muscle thus leaving an important communicating branch from the brachial plexus, we severed the nerve trunk at a point where it is deflected from the pericardium to the diaphragm on the left side. Fluoroscopic examination showed that the loss of innervation left this side of the diaphragm comparatively motionless. It no longer contracted during inspiration. On the contrary it maintained a somewhat higher level than normal during expiration and during inspiration it went up instead of down. (Fig. 12.) Thus, during respiration after one phrenic nerve was

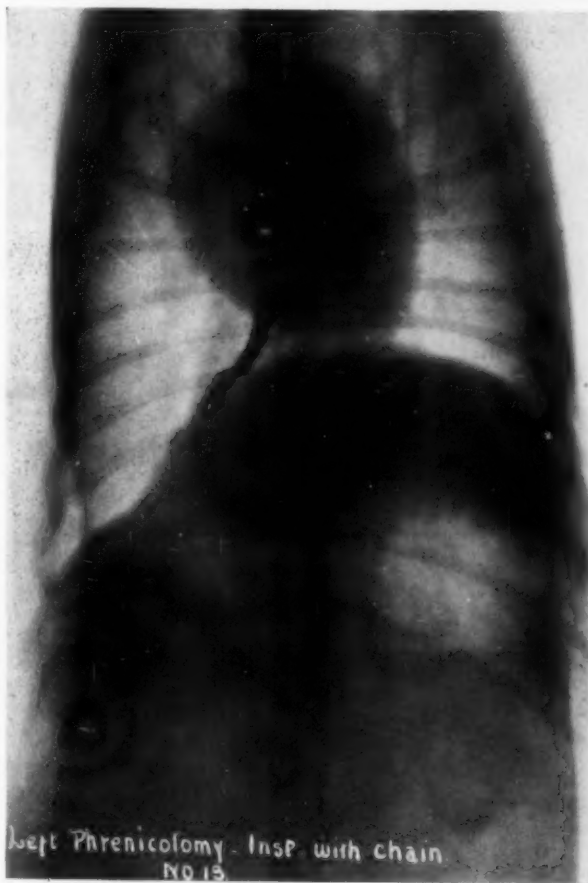


FIG. 12.—Left phrenicotomy. Chain in œsophagus. Inspiration. Paralysis of left diaphragm. Deflection of trachea and œsophagus toward the right. Torsion of lower end of œsophagus.

severed, the two sides of the diaphragm exercised an alternating motion, sawing up and down. Dr. M. C. Sosman upon examining the Röntgen-ray films termed this the "paradoxical" action of the diaphragm.

Another effect of phrenicotomy and of more practical significance than eventration was a deformity produced at the lower end of the œsophagus during the period of contraction of the innervated leaf of the diaphragm. There was observed a loss of that well-balanced pull on the lower end of the œsophagus which takes place in the normal diaphragm. The innervated leaf contracting as usual drew the cardiac end of the œsophagus with it. (Fig. 13.)

Not only was the œsophagus thus displaced two or three centimeters laterally, but, by the action of the muscle fibers opposing the paralyzed leaf, it was given a rotary motion. In order to study this altered mechanism at this point a rubber tube filled with barium was passed into the stomach. But in addition to being perfectly round this acted as a splint. Thereupon, Dr. Cushing

suggested the use of a metal chain made on a flat pattern. (Fig. 11.) We found that this served our purpose admirably. While we could not measure accurately the degrees of rotation of the cardiac end of the œsophagus nor the exact distance of lateral displacement, it was apparent that they were circumstances, to produce sufficient, under certain altered function at this segment of the alimentary tract. A case of this sort following an operation for cervical rib came under the observation of Dr. Cushing in which the symptoms were suggestive of cardiospasm.

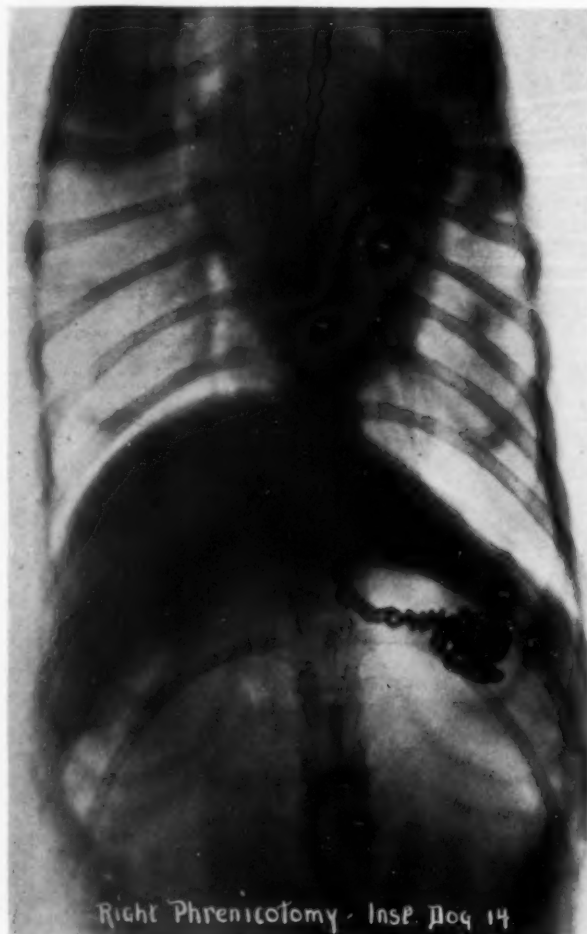


FIG. 13.—Right phrenicotomy. Chain in œsophagus. Inspiration. Paralysis of right diaphragm. Deflection of trachea and œsophagus toward the left. Torsion of lower end of œsophagus.

breech presentation. The extraction of the head was accomplished with difficulty. The infant suffered from attacks of cyanosis and dyspnoea. There was an obstetrical paralysis of the right arm. On examination of the chest the percussion note was flat up to the level of the third rib. Respiratory sounds were absent over this area. The X-ray film showed the heart displaced to the left and the liver ostensibly in the right side of the chest. Under the fluoroscope, however, the "paradoxical diaphragm" was demonstrated. The child died four weeks later and the diagnosis of eventration was confirmed at autopsy. Here then was positive evidence of paralysis of the right leaf of the diaphragm with a marked degree of eventration as a concomitant deformity with brachial paralysis. This question seems pertinent: May not this form of phrenic nerve paralysis account for some of the cases of eventration of the diaphragm seen in adult life?

Two other cases of this "paradoxical action" of the diaphragm have been observed in our clinic. One came under the observation of Dr. George C. King: a baby of two weeks born in

## CONGENITAL HERNIA AND RUPTURE OF DIAPHRAGM

Another case of the "paradoxical diaphragm" has been recognized by our Röntgenologist, Dr. J. H. Lindsey. The patient was a woman who, four years previously, had been operated upon for cancer of the breast. She returned on account of vague symptoms of the upper abdomen and chest. An X-ray film revealed paralysis of the left leaf of the diaphragm and evidence of metastasis in the mediastinal glands which apparently was the cause of pressure on the phrenic nerve on the same side.

These experimental and clinical observations are not advanced as a contraindication to phrenicotomy for pulmonary tuberculosis or as a preliminary operation to the repair of those cases of diaphragmatic hernia in which closure of the hernia orifice is expected to be very difficult or otherwise impossible. They bring into notice, however, the debilitating effect of phrenicotomy on the action of the diaphragm and the associated distortion of the cardiac end of the œsophagus, which in some cases may be the cause of symptoms difficult to explain.

DISCUSSION: DR. CARL A. HEDBLÖM, of Chicago, Ill., remarked that in drawing conclusions with reference to the human intrathoracic pressure changes from experimental observations on the dog, one must take cognizance of the fact that in the human the normal mediastinum possesses a much greater degree of stability than that of the dog. Second, that paralysis of the diaphragm seems to me of no particular advantage in the repair of a hernia at the œsophageal ring, inasmuch as there is little or no mobility of the diaphragm in this region. In case of a traumatic rupture in or near its central portion a temporary paralysis is of great advantage and can be achieved by simply crushing the nerve in the neck with a pair of hemostats.

Paralysis of the diaphragm by phrenic nerve resection or extraction has in recent years found a very extensive field of usefulness, particularly in the treatment of pulmonary tuberculosis. I have never seen or heard of any serious detrimental effect of such paralysis of the diaphragm.

DR. EMIL GOETSCH, of Brooklyn, New York, related the case of a child seven or eight years of age, who had been knocked down by an automobile. Immediately after the injury there was remarkably little complaint. The child said she had a little pain in the side but that was about all. She was kept out of school for two or three days and soon returned. She went on, and for the following year and a half she had pain only while playing. After that she said she had a "sideache." That was really all she complained of.

The symptom continued. She came to the medical clinic at the hospital and by a simple routine examination a marked dextrocardia was found. Not because the patient was in a bad condition but because of the dextrocardia she was taken to the hospital for further study. There the barium enema revealed most of the colon in the left thorax. Then, further studies with barium by mouth showed the stomach to be there too.

The operation in this instance was a left thoracotomy without cutting the ribs, simply a spreading of the ribs by a mechanical spreader. The operation itself was carried out relatively easily. The ribs were retracted and a large rent was found extending from the periphery of the diaphragm to the peri-



## DISCUSSION

cardium. The phrenic nerve was clearly visible. It was not torn because of the accident, but it was reflected to the pericardium and the diaphragm.

Inclosing the opening he freshened the edges of the wound because they were clearly glistening, like the peritoneum and he thought that when he brought them together there might be no healing. He therefore refreshed the edges and freed the pleura and peritoneum, closed them with catgut and reënforsed with fine silk. The wound margins were brought together by a silk suture around the ribs and an airtight closure was made. The lung was collapsed. Following the operation there was a pleural effusion but the pleural fluid soon was absorbed and the lung expanded. The function of the left diaphragm rapidly became normal. The patient made a wonderful recovery and was found to be in excellent shape very soon after the operation.

## RESECTION OF RECTUM FOR CANCER AND CONTINUITY RESTORED

By WILLIAM F. VERDI, M.D.

OF NEW HAVEN, CONN.

It is not our purpose in this paper to criticize the work of other surgeons or to question the results obtained by them. The following remarks upon rectal cancer are based upon a rather extensive experience in the surgical treatment of this disease. We do not claim any originality in our work. We have availed ourselves of methods described by other surgeons in situations where they served our purpose the best. The best results have been obtained in those patients in whom the tributary lymph nodes have not shown extensive metastatic deposits to the naked eye, to the feel or to microscopic examination. In cases where there is extensive glandular involvement, local recurrence and distant metastasis is prone to occur regardless of how extensive the operation may have been. A better outlook may be expected in those cases where the growth is more localized.

Cancer begins as a localized disease and has varying degrees of rapidity in its spread. This depends chiefly upon the location in which it first develops, its virulency and the amount of defense the patient possesses. It is singular that in two positions where cancer has a tendency to start it spreads slowly and remains local for a long time. Both are positions where surgical attack is difficult, but both represent a type of cancer which runs a slow course and is considered clinically less malignant. Cancer of the œsophagus destroys life by starvation much more frequently than it does by extension of the disease and rarely by metastasis. Cancer of the rectum is very much more easily removed than cancer of the œsophagus and involves a less vital structure.

Because cancer of the rectum tends to remain local for a long time and grows by direct extension of the disease with late metastasis, we are endeavoring to treat the favorable cases by a less extensive resection than is advocated by other surgeons. The advocates of the abdominoperineal operation claim a greater percentage of cures than is obtained by other methods. We do not perform this operation because of the high mortality it has given us. Those cases of cancer of the rectum which are above the cul-de-sac and too high to be removed through the sacral operation are removed through the abdomen, but we simply remove the tumor by a wide excision and leave the patient with a permanent colostomy. We make no effort to remove the entire bowel including the anus.

The intricate network of lymphatics and their wide distribution to the pelvic glands is a great drawback to a block dissection such as is performed for cancer of the tongue or for cancer of the breast. A so-called radical operation for cancer of the rectum would necessitate the removal of all the

pelvic organs, a manifestly impossible operation. When a cancer of the rectum has invaded the prostate or the bladder or has become attached to the pelvic floor and is immovable and fixed, it is considered to be inoperable and a simple colostomy gives an immense amount of relief and prolongation of life.

All the cases which can be felt by digital examination, are below the cul-de-sac and do not involve the anus are operated upon through the sacral route. Every patient with cancer of the rectum is first explored through an abdominal incision. We are not satisfied to resect a rectum below the cul-de-sac without first carefully exploring the abdomen for enlarged glands or liver metastasis.

In the last nine years sixty cases of cancer of the rectum have come under our care. Thirty-four of these cases were men and twenty-six women. In fifteen of these cases it was possible to restore the continuity of the bowel and preserve the action of the sphincter muscle. The first case of this series, a man, is living, well and attending to his occupation nine years after the operation. There is only one case dead, a woman, and she lived for five years after the operation. The others are all in good condition and attending to their daily duties and thus far present no sign of recurrence. Ten of these were operated upon through the sacral route and five through the abdomen.

The majority of our cases, twenty in number, have occurred between the ages of fifty and sixty. The next in frequency, seventeen, were between sixty and seventy, seven were between forty and fifty, five between seventy and eighty, five between thirty-two and forty, five no ages were given and one at the age of twelve. The youngest was twelve years and the oldest seventy-six years of age. In twenty-seven cases the tumor was resected, leaving the patient with a permanent colostomy. In eighteen cases, which were inoperable, a simple colostomy was performed. In fifteen cases in which the tumor was removed, the colostomy was closed and the continuity of the bowel restored. There were thirty-two cases which were operated upon through the sacrum for cancer below the cul-de-sac within reach of the examining finger. All the others, except those where a simple colostomy was performed, were operated upon through the abdomen and five of them had an end-to-end anastomosis performed and the colostomy closed. One of these died from metastasis five years after. The other four are still living, the longest living nine years after the operation. The other ten cases, in all of which the continuity of the bowel was restored, are living and the time which has elapsed since the operation is as follows: One, nine years; one, eight years; four, four years; two, two years; two, seventeen months; two others, in the hospital at the present time, have had the sigmoid brought down but the colostomy has not yet been closed.

Cancer of the rectum is not a very malignant disease as compared with cancer in other parts of the body. The disease does run a rapid course in some patients but in our series this has not occurred very often. An operation for cancer, regardless of its position in the body, should be made as

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complete as the exigencies of the case will allow. The lymphatics and the lymph glands which are likely to become involved in the extension of the disease should be accurately known. It is impossible to consider any operation for cancer a radical one, since the term implies a complete removal of every cancer cell and this, for obvious reasons, cannot be positively ascertained. The advocates of the abdominoperineal operation, with its attending high operative mortality, make the claim that this procedure, because of its extensive removal of tissue, offers a better chance for a cure than any other form of operation. The German statistics give the mortality rate of the abdominoperineal operation as 50 per cent., while the sacral route claims a mortality of 25 per cent. Jones gives a mortality of the abdominoperineal route as 23 per cent. Of the sixty cases of cancer of the rectum which we have operated upon there were only seven cases in which this method was employed and four of them died within a few days after the operation. The other fifty-three cases, which were operated upon by a preliminary colostomy followed by a sacral operation where the cancer was situated below the cul-de-sac and by a high operation where the growth was above the cul-de-sac, gave a mortality of not more than 12 per cent. We think it is generally conceded that an operation through the sacrum after a preliminary colostomy has a much lower operative death rate than any other form of operation. The best cases, in which it is possible to restore the continuity of the bowel, are those in which the cancer is located below the cul-de-sac and sufficiently far above the sphincter not to involve the lymphatics which go to the glands in Scarpa's triangle; that is the anus is not involved. Those above the cul-de-sac are best operated upon through the abdomen and in five of these cases it was possible to restore the continuity by an end-to-end anastomosis. One of these cases operated upon in 1921, the longest living of this group, is still well. One of these died from metastasis five years after the operation.

The majority of our cases show a comparatively low grade of malignancy. We have seen few instances of the truly annular type of tumor which is not infrequently seen higher up in the intestine. The common picture is that of an apparently slow-growing type of tumor which projects into the lumen of the rectum and becomes secondarily ulcerated and infected. The growth may be limited to one portion of the wall or may have involved the whole circumference. It begins as an indurated, raised area which soon becomes umbilicated and necrotic in the centre with a hard infiltrating margin. It grows much like a ringworm and progresses until it involves the whole circumference of the lining mucous membrane of the rectum. We have observed these cases from a size not much larger than a twenty-five cent piece, through all stages of involvement of the lumen until they finally meet at the periphery. They grow both in the longitudinal and in the lateral direction. They invade the rectal wall and destroy the mucous membrane as they advance. The extent of the invasion of the rectal wall is not easily determined clinically because of the induration due to infection; it must, therefore, be judged from the microscopic section.

Histologically these rectal tumors seem to belong in a group by themselves. Whether one classifies them as adenoma destruens, the term used in Doctor Ewing's book on neoplasms, or by estimating their degree of malignancy by grading according to the method of Broders, makes little difference. The average tumor is made up of groups of irregular glands which closely adhere in general morphology to the original structure of the mucosa. The cells tend to be columnar and comparatively adult in type, often showing the ability to produce mucus. There may be marked variation in the size of the cell and in the distribution of the chromatin within the nuclei. The number of mitotic division figures varies.

These tumors do not show evidence of rapid growth. Thus our series of rectal carcinomata seem to belong to the relatively benign group and might be estimated as belonging to grade two as described by Broders. It has been our experience that such tumors tend to spread mainly by direct extension and do not show the same predisposition to produce apparently isolated growths in the lymph-node metastasis. Doctor Ewing's "Neoplastic Diseases," third edition, page 711, makes the statement, "that metastasis in the adjacent lymph nodes is common in autopsy material but less frequent in operative cases." This would seem to substantiate the contention that in the comparatively early primarily operative cases lymph-node involvement is not the outstanding feature that it is in other types of malignant neoplasm.

*Lymphatics.*—The lymphatics of the colon follow the blood vessels of the mesenteric system. In the rectum the lymph system is more complex. Grota describes four rectal groups:

1. The anal vessels form four to five branches which traverse the skin of the perineum and thigh and reach the inguinal nodes in Scarpa's triangle. Other deeper branches join with those of the zona intermedia and reach the anorectal nodes.
2. Branches from the zona intermedia pass backward and follow the superior hæmorrhoidal veins to the anorectal nodes but occasionally branches pass to a node at the foramen ischiadicum (Quenu's node).
3. Branches from the zona columnaris follow the same course.
4. The pars pelvina is chained by vessels which pass below to the anorectal nodes and above to the mesenteric nodes of the colon. Lymph nodes are missing in the wall of the anal portion but are abundant in the fat tissue lying between the muscular wall of the pelvis and intermediate segments and the rectal fascia. In fifty-nine post-mortems collected by Kraske and Iverson, metastases were present in thirty-two—in nodes, liver, peritoneum, lungs and brain. They usually reproduce the original structure. From these data and from the long duration of most cases it is clear that carcinoma of the rectum is a favorable field for aggressive treatment.

A general outline and sequence of the different stages of the operation performed follows:

The operation performed for restoration of the bowel in cancer of the rectum below the cul-de-sac and not involving the anus consists in a median



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suprapubic laparotomy with a very careful exploration of the pelvis for glands and peritoneal metastasis in the cul-de-sac. The mobility of the tumor, and its attachments to the surrounding organs such as the prostate, ureter and bladder, should be carefully noted. A thorough exploration of the glands along the external iliac and inferior mesenteric arteries and a careful exploration of the liver should be carried out. The lack of invasion of the lymphatics, peritoneum and liver determine the type of operation to be performed. If, in our judgment, after every condition has been carefully noted, a sacral operation can be performed, a loop of the sigmoid above the sacro-iliac joint and near the descending colon is brought out through a left-sided, gridiron incision, thus leaving the entire sigmoid for mobilization to be brought down and attached to the anus after the removal of the growth has been accomplished. The loop of gut in the left iliac region is opened in forty-eight hours with a cautery.

This we consider the first stage of this operation for the restoration of the continuity of the bowel and it is performed under general anæsthesia in order that complete relaxation may occur and a thorough exploration, visual and manual, may be made. The second stage of this operation is undertaken not earlier than two weeks after the first stage. This allows sufficient time for the colostomy to function well. However, by far the most important point of the delay prior to the second operation is the subsidence of the infection which involves the tumor.

In the performance of the second stage of the operation, sacral or spinal anæsthesia is employed. We have used both and we have come to the conclusion that spinal anæsthesia is preferable. The coccyx with two or three segments of the sacrum is completely removed. We do not believe in an osteoplastic flap. By careful dissection, with as little pushing and tugging as possible, we make a circular dissection of the bowel above the internal sphincter. With the finger hooked around the whole circumference of the bowel, the rectum is divided after a small Payr clamp has been securely fixed to the rectum above the point of division. A cautery may be used to make this division. The upper dissection of the rectum is then started. The rectum is dissected free from the prostate, the ureters are often brought into full view and in the majority of cases the cul-de-sac is opened and the peritoneum divided as it passes from the bladder wall to the rectum and gently and firmly the whole rectum is delivered through the sacral wound. In performing this dissection extreme care is observed not to injure the rectal wall thus allowing the escape into the wound of purulent bloody material rich in cancer cells. All the rectal and areolar tissue in the cavity of the sacrum is removed leaving only the fascia covering the pelvic wall itself. It has been our experience to find indurated adherent glands along both lateral walls of the rectum. We try to keep well outside of this area. The most important consideration is the preservation of the blood supply. Several large rectal arteries which enter the rectum laterally must be severed. It is important to preserve the main branches of the superior hæmorrhoidal artery.

After the whole rectum, including the sigmoid, has been delivered through the sacral wound the bowel is divided well above the tumor and the sigmoid, when all the bleeding has been checked, is brought down, sometimes under considerable tension. As it passes through the dilated sphincter it is attached to the mucocutaneous margin of the anus with interrupted chromic catgut sutures not unlike the Whitehead operation for hæmorrhoids. The wound is only partially closed and is drained with large Penrose tubing packed with iodoform gauze. It would be very fortunate if this union would hold in every case but it seldom does and a second and sometimes a third operation is necessary before the union is complete.

The final operation is not performed earlier than from two to four months after the second. The perineal wound must be entirely closed and the continuity of the bowel must be complete and free from stricture before the colostomy is closed and the bowel contents are allowed to continue their normal course. The operation is difficult, disappointing and trying to the patient but the end sought is worth all the trials and tribulations which both the surgeon and the patient must endure. As has been previously stated there are fifteen patients out of the sixty who have successfully gone through this procedure with but one death, from metastasis, five years later. The patient is ordered to report once every two or three weeks for a few months and a digital examination is made to make certain that no stricture formation occurs. In none of my cases have I observed any growth in the perineum or anal region such as has been described by Miles and it is my belief that the downward extension of the lymphatics which he claims in the normal individual does not exist, but that what happens in fact is an implantation of cancer cells occurring at the time of operation. The lymphatics run mainly in an upward and lateral direction but not downward. In those cases which involve the anus the lymphatics go to Scarpa's triangle. The removal of all the glands along the external iliac artery and the inferior mesenteric in the course of an operation for cancer of the rectum is accomplished with enormous difficulties. The mere fact that these glands are always palpable, are always firm, are always enlarged does not mean that they contain metastases.

In conclusion it is our feeling, judging from the success we have had in this series of cases that it is well worth while to attempt a restoration of the continuity of the bowel more often than has hitherto been attempted. This procedure has a lower operative death rate and the patients are more comfortable and are restored to work. We could have had a larger number to report if many patients had not come so late. So the important criterion in this, as in all other forms of cancer, is early diagnosis.

## END RESULTS OF RADICAL OPERATIONS FOR CARCINOMA OF THE RECTUM

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UNTIL about fifteen years ago, the physician might well have said that he would not send his patients with carcinoma of the colon and rectum to the surgeon because the results were not good enough and the mortality was too high. While that may have been a legitimate reason at that time, it no longer holds, for the operation has been much improved and the mortality is within reasonable limits. With a disease which would undoubtedly give a high percentage of five-year cures, or even permanent cures if operated upon early, we cannot be satisfied with the interest shown in the diagnosis of these cases by the surgeon or by the physician. It is the duty of the surgeon to stimulate interest in any subject within his province, among the laity and medical profession. It is the duty of the physician to place such diseases among those which he should recognize, and give them the proportionate amount of attention their importance deserves. It is evident at the present time that the physician has not placed a very great importance upon the diagnosis of carcinoma of the colon and rectum, and this applies to many physicians in large hospitals as well as to the family physician. It is rather disturbing to find patients being sent out from hospitals because the X-ray shows no lesion, and in spite of the fact that there is a typical history of cancer of the colon or rectum, or to be told by practicing physicians that they rarely send a case of carcinoma of the colon or rectum to the surgeon, because there is no use in it, or frequently to see patients who have been told that nothing can be done for them. This is a subject which deserves more consideration from the surgeon, and the physician, for it is of much greater frequency than is generally supposed, and is of much greater importance to the patient than many medical conditions upon which much time and effort are spent. It is undoubtedly true that many cases are never seen either by a medical or surgical consultant.

*Diagnosis.*—It is difficult to speak of the diagnosis of a disease which should be diagnosticated, in 100 per cent. of the cases presenting themselves. It is true that the patient must first present himself, but this we can expect when more interest is taken in the disease by the profession. The diagnosis is made a complicated procedure by many textbooks which stress late symptoms, while as a matter of fact we should be looking for the very early symptoms. Blood in the stool and any change in bowel habit or sensation are the early symptoms, in fact almost the only symptoms of value at any time, and physicians and patients should be made familiar with them. While any change in bowel habit or sensation is an early symptom, in these days of oils and cathartics little attention is paid to the slight irritation of the

intestine which the growth causes. This irritation may result in an increase in the number of movements, a sensation of increased gas in the intestines, or a sensation of inability to empty the intestine. Attention to minor details of this sort would put forward the diagnosis of this condition several months. Constipation, now recognized as an early symptom, is not present until several months later than formerly because of the use of oils which soften the movement without causing pain. It is never an early symptom because the growth must have reached the stage of obstructing the bowel to some extent before it is noted. In spite of the use of oils and cathartics, it would be possible to train the laity to recognize the irritative stage of the growth in many cases if interest in the disease could be aroused in the medical profession.

Blood in the stool, either macroscopic or microscopic, is undoubtedly a very early symptom and probably the most valuable single symptom we have, in spite of the fact that it is frequently not present. A careful search for blood in the stool suggested by any of the early irritative symptoms of the growth would make an early diagnosis possible in many cases. Blood is also present with polyps of the colon or rectum, a condition we have come more and more to believe to be of great importance, of even greater importance than carcinoma itself, for polyps frequently become carcinoma, and proper treatment before they become malignant means permanent cure. The symptoms of polyps of the colon or rectum are identical with those of early carcinoma.

It is unfortunate that at the present time many physicians and every layman believes that hemorrhoids of any kind cause pain and bleeding. It is true that internal hemorrhoids do bleed frequently, but it is a much more important fact that carcinomata and polyps bleed. It would seem reasonable to expect the medical schools of the country to start students out with this fact uppermost in their minds, rather than with the idea that all bleeding is from hemorrhoids. If every physician and every surgeon would determine accurately the location of the source of bleeding by digital and proctoscopic examinations, the operability of cancer of the colon and rectum would be greatly increased and the number of actual cures would be high. The removal of polyps alone would undoubtedly save many, probably more than the removal of the early carcinomata. If the accurate determination of the source of blood in the stools were attempted, physicians and surgeons would not treat carcinoma for chronic ulcerative colitis, for when present the lesions of chronic ulcerative colitis can always be seen through the sigmoidoscope. If a normal rectum is seen and blood is seen coming from above, the diagnosis of an ulceration or polyp higher up in the colon can be made, and that ulceration is carcinoma in at least 90 per cent. of the cases.

The statement has been made frequently that diverticulitis causes bleeding. It may be true that diverticulitis in the very acute stage causes a very small amount of bleeding, but for practical purposes diverticulitis does not cause bleeding. If after the acute stage has quieted down there is blood in the stool, the diagnosis of carcinoma should always be made.

## END RESULTS OF RECTAL CANCER OPERATIONS

The sigmoidoscope is an instrument still reserved for the specialist to too great an extent. It is a necessary instrument in the diagnosis of diseases of the colon and rectum, and should be used constantly by every internist and surgeon. An efficient instrument for wiping the surface should be added to the equipment, for inability to see the surface of the bowel clearly has led to serious errors.

The diagnosis of carcinoma of the rectum can always be made by digital or sigmoidoscope examination; it is, therefore, useless and often misleading to make an X-ray examination until carcinoma of the rectum has been positively excluded. If no disease sufficient to cause the symptoms is found by the sigmoidoscope, an X-ray examination of the remainder of the colon should be made. A point which may be of value is that polyps and carcinoma are frequently found on the anterior surface of the rectum between fourteen and sixteen centimetres above the external orifice. At this point, there is a fold which it is frequently difficult to get beyond, especially with the patient in the knee-chest position. In the effort to get the instrument over this fold, a polyp or small growth may easily be covered by it. This error can be avoided by making a careful inspection of the whole rectum as the instrument is withdrawn.

As the diagnosis can be made in every case of carcinoma of the rectum by digital and sigmoidoscopic examinations, all that is needed is confirmation by the microscope in a certain small number of cases. Probably the greatest number of mistakes are made in the group of polypoid growths, for it is often impossible to distinguish carcinoma from polyp or *vice versa* by digital, proctoscopic or microscopic examination. If the growth is carcinoma, the malignancy is often found only at the base, from which it is almost impossible to get a section for examination. Recently we have adopted the method of removing the polyp with the high frequency current and then examining the rectum at weekly intervals. If any suspicious area is seen, it is removed with a curette and examined under the microscope. In this way, unnecessarily extensive operations can be avoided, or extensive operations done when malignant disease is found.

*Treatment.*—The treatment of carcinoma of the rectum may be roughly divided into three periods. The first extended up to 1885. During this period, nothing but palliative operations, such as colostomies, section of the sphincter and growth, and curettage were done. The second period extended from 1885 to 1912. Kraske brought out his operation in 1885, but it was too radical for the time and little was done with it for ten years. In 1895, Treves wrote: "Excision of the rectum is now a thoroughly established operation and although it met a great deal of opposition in England, it is now pretty generally adopted as the best treatment in selected cases." Selected cases meant 20 to 25 per cent. of the cases seen. Many variations on the Kraske operation for excision of the rectum by the posterior route were brought out during this period. The sacral or perineal anus was usually made when the growth was removed. In this period, 25 per cent. or less



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of the patients seen were operated upon, and from 23 to 28 per cent. of those operated upon lived three years.

In the third period extending from 1912 to the present time, the abdominoperineal operation has been struggling for recognition. Czerny published a paper on an abdominoperineal operation in 1883, but little or no attention was paid to it until Mr. Ernest Miles again advocated it in 1912. After a careful study of the lymphatic drainage of the rectum, he was convinced that anatomically at least the combined abdominoperineal operation was the logical one to use, but it met with much opposition in England and has made slow progress everywhere. There were three important objections to the operation: (1) The permanent colostomy; (2), the immediate mortality was too high; (3), it was a long, tedious, and many times difficult operation.

The objections to the colostomy are much exaggerated in the minds of the patient, many surgeons and especially the family physician. The patient naturally objects when told that there is no voluntary control, and the idea of the bowel emptying itself upon the abdominal wall is revolting. He naturally must be made to see the necessity of such a procedure, and should have the backing not only of the surgeon, but particularly of the family physician. It is difficult for the surgeon and family physician, who are well, to imagine themselves in any position when such an operation would be necessary. Many surgeons and physicians know only the colostomy which is done as a last resort, and the family physician has rarely seen one when the patient has been relieved of the growth in addition to the colostomy. Until the surgeon and family physician can be trained to believe that the colostomy is not an impossible burden, we cannot hope to persuade the patient to submit to it. To really appreciate the advantages of a colostomy, the patient should be constantly uncomfortable before operation, as most patients with cancer of the rectum are. Very few patients with cancer of the rectum would refuse a colostomy if the reasons for it were explained, and if the family physician would join in aiding the surgeon to persuade the patient. Unfortunately the family physician too often agrees with the patient that he had better be dead than have a colostomy. To answer all arguments against a colostomy, it seems necessary only to state the truth, which is that all patients with a colostomy and removal of the growth live happy and contented lives. A colostomy without removal of the growth should not be compared with the comfort a patient gets with a colostomy and removal of the growth. Patients with a colostomy alone, not infrequently commit suicide, while we have never had one attempt it who has had a colostomy and removal of the growth. The surgeon must be convinced of the value of any operation which requires a colostomy. The statistics giving the percentage of patients operated upon and the percentage of patients living three and five years after the various operations should be sufficiently convincing that the combined abdominoperineal operation gives results which justify a colostomy.

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Much has been written about colostomies, which give control of the bowel; in fact, the publication of a new operation which will control the bowel after a colostomy is almost as frequent as the presentation of a new model for a needle holder! The only method of controlling the bowel that we know about is to teach the patient how to get the bowels constipated and how to move them once in twenty-four or forty-eight hours, usually without cathartics. To teach the patient to take an interest in his colostomy is the only road to success. No colostomy yet presented will prevent the passage of gas and soft fecal matter. There is little use in discussing the advantages or disadvantages of the colostomy over the perineal or sacral anus as advocated by some Italians. It seems probable that the posterior anus is the choice of the surgeon rather than the patient.

The second objection to the combined operation is the high mortality. This should not be considered too seriously in a disease like carcinoma of the rectum so long as it is kept within reasonable limits, that is, 15 per cent. or below. The mortality has been high, up to 50 per cent., but this was during the early days of the operation. One important reason for a high mortality was the attempt to operate upon all patients by this method.

The third objection to the operation, the length and difficulty of it in some cases, must be admitted and only those who are willing to accept these conditions as part of the operation should undertake it.

During the last ten years, many operations have been presented, usually old operations dressed up in new clothes. The resections, and the various posterior operations, are undoubtedly carried out more carefully, but the amount of tissue removed is the same, and it is doubtful if the three-and-five-year cures are much greater, although the mortality has been lowered.

The combined abdominoperineal operation in one stage approaches nearest to the ideal operation of any yet presented, in that the growth can be removed wherever situated in the rectum, and it can be removed with the greatest amount of tissue, that is, the greatest area of lymphatic drainage. These facts permit removal of the growth in a greater number of cases and give a higher percentage of three-and-five-year cures than any other operation.

It is unfortunate that surgeons have felt obliged to confine themselves to one operation for cancer of the rectum, for even the combined operation in one stage which permits the removal of any growth anatomically, limits the number of patients operated upon because certain poor risk patients cannot withstand such an extensive procedure. Removal of the growth in every case in which it is possible to do it should be the object of everyone and to do this other operations than the combined abdominoperineal operation in one stage, which may be considered the ideal operation to be carried out if possible, must be used. Probably greater harm has been done by this attempt to apply one operation to every case of carcinoma of the rectum than anything else. It is true that an effort should be made to improve the results obtained by the posterior operation, and undoubtedly the combined abdomino-

perineal operation is best suited to it, but poor risk patients should not be neglected because the operation which the surgeon favors is too severe. If we confine ourselves to an operation which can be used even on the feeble, we are not doing justice to those who can stand a more extensive operation. Statistics are now available for nearly all types of operations and the time has passed for presenting small groups of cases operated upon by some method which gives a low mortality in that particular series, or which removes the growth and avoids a colostomy. It must be appreciated by this time that any resection for carcinoma of the rectum, or any posterior excision cannot remove the same amount of tissue or the same amount of lymphatic drainage that the combined abdominoperineal operation does. It may be true that it is useless to remove more than the local growth and the tissue surrounding it, but if that is so, statistics should prove it. Until it has been proved that the extensive removal of bowel and area of lymphatic drainage gives no better percentage of three-year cures than the lesser operations, it is logical to continue to use the more extensive operations in suitable cases. Up to the present time, no series presented gives sufficiently good results to make any operation acceptable as the only operation to be used. Every surgeon who has operated upon cases of carcinoma of the rectum can report a case in which a local excision was done and the patient has lived fourteen years or more, but that does not mean that a reasonable percentage would live three or five years, if a large number of cases were operated upon by that method. While we believe that the combined abdominoperineal operation in one stage is the operation of choice in proper cases, a great error has been made in trying to use it on every patient. It is useless to deny that the operation if used on all cases would give too high a mortality and that would soon have the effect of cutting down the number of patients operated upon, and as one of the fundamental principles of the treatment of carcinoma of the rectum should be to remove the growth in every patient when possible, whether a cure can be expected or not, less severe and less extensive operations must be used in addition to the ideal operation. The percentage of patients operated upon and the mortality will depend to a very considerable extent upon the selection of the proper operation for each case, but it should always be remembered that the most extensive operation which the patient will stand should be our object. It is our belief that at least five operations are necessary to make it possible to remove the growth in the greatest possible number of cases.

Next in severity to the combined abdominoperineal operation in one stage is the same operation done in two stages, or the two-stage operation of Coffey. In the combined abdominoperineal operation in two stages, as carried out by the writer, the same dissection is made and the same amount of tissue is removed as in the one-stage operation. A lateral colostomy is made above the point at which the bowel will be sectioned at the second operation. The arches from the left colic artery remain intact to supply the portion of bowel placed below the peritoneal flaps, but the inferior mesenteric

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artery is tied. The objection to this operation is that the growth is left *in situ* after the pelvic dissection, until the posterior operation is done a week later. It is the operation of choice in high growths in old, feeble and fat patients, especially men. It should be the operation of choice no matter where the growth is in patients who can stand it, but who are not quite able to stand the one-stage operation. The decision as to whether to make a one- or two-stage operation can be left until just before the peritoneal flaps have been closed over the pelvis, as the blood supply is left intact up to that point. Our statistics show nearly as high a percentage of three- and five-year cures by this method as by the single-stage operation, in spite of the apparent objection to it.

This operation is too severe for some old, feeble and fat patients with low growths; in such cases the third operation which consists of a colostomy without dissection above, followed in one, two or three weeks by an excision of the rectum by the posterior route should be used. While Mummery gives statistics which show nearly as high a percentage of three- and five-year cures as the combined operation, and a much lower mortality, such statistics must require great experience in the selection of cases, for much less tissue is removed.

A fourth operation is that presented by William J. Mayo in 1912, and recently advocated by Rankin. It consists in dissecting the pelvis very much as in the combined abdominoperineal operation to well below the growth. The bowel is double clamped and cut across as low as possible in the pelvis. The distal end is then closed and the proximal end brought out for a colostomy after removal of the growth, lower portion of the sigmoid, and the greater portion of the rectum. This operation is exceedingly useful in high growths in poor risk patients. Up to the present time, we have had two cases in which there has been a recurrence in the pelvis with involvement of the remaining portion of the rectum with return of distressing rectal symptoms.

A fifth operation is necessary in early and favorable growths situated at a proper height, above the sphincter, to make preservation of it appear to be a reasonable procedure. For this operation, we have used the combined abdominoperineal operation in one stage, and have brought the sigmoid down through the sphincter. This method has been given preference over a resection and end-to-end suture, because we believe that a greater amount of possibly infected tissue is removed and the section of the bowel below is farther from the growth. There is always danger of necrosis because of injury to the blood supply, but there is no danger of fistula as in resections, which is, we believe, as annoying to the patient as a colostomy. In the last operation, grading of the growth is of the greatest importance, for a highly malignant one should always be removed by the most extensive operation possible.

In the combined operations, Whipple has suggested a preliminary cecostomy if there has been much obstruction. This would undoubtedly be



a great aid to improving the condition of the patient and would in that way lower the mortality very considerably.

It must be evident to anyone doing this work that it is impossible to use the same operation in every case, if we wish to operate upon the greatest possible number of patients. Age, sex, degree of obstruction, variations in the anatomy of the pelvis, amount of retroperitoneal and abdominal fat, the size and position of the growth, the amount of involvement of perirectal tissue and lymphatics, and the general condition of the patient are all so variable, it is unreasonable to depend upon one type of operation. The familiarity of the surgeon with, and his ability to carry out the various operations must have much weight in determining what operation shall be used in any particular case. It is true that there is a standard operation for the great majority of surgical diseases, but if we are to operate upon the greatest possible number of patients with a reasonable mortality and the highest possible percentage of three- and five-year cures, it is impossible to operate upon cases of carcinoma of the rectum by one type of operation.

It must not be forgotten that we still have radium to fall back upon in inoperable cases and in patients too old or too feeble to withstand any of the five operations mentioned above. Radium cannot be used to advantage in many high growths and should not be used in growths close enough to the sphincter to cause a radium burn of it. The pain in such cases is severe and prolonged for months.

In the following tables, we are presenting statistics of a series of cases operated upon in a large teaching hospital; another series operated upon in smaller hospitals with expert assistants. The difference is disturbing, but we have been unable with every effort to make the mortality of the teaching hospital approach that of the private hospital with expert assistants. These patients are frequently quite ill after operation and only the most careful attention by men experienced in this work will detect early, serious symptoms. At the present time, by far the most frequent cause of death is intestinal obstruction. These patients slide very quietly into intestinal obstruction with such unobtrusive symptoms that the condition is often not recognized even by the experienced until it is too late. Peritonitis has almost entirely disappeared, and hæmorrhage is only of secondary importance.

Statistics are of little value unless some uniform scheme for reporting results is adopted. It is particularly true of such conditions as carcinoma of the rectum in which certain operations are of value in only a very small percentage of cases. In a small and well-selected group, the mortality may be low and the number of cases living three and five years high. Up to 1912, less than 25 per cent. of the cases seen by surgeons of considerable experience were operated upon. In certain operations advocated at the present time not more than 25 per cent. could be operated upon by that method. It is useless to compare the results of a series in which 25 per



## END RESULTS OF RECTAL CANCER OPERATIONS

cent. are operated upon with those of a series in which 55 per cent. are operated upon.

The series of cases presented for consideration in this paper includes 285 in which the growth was removed. This is 53 per cent. of the cases examined. During the last three years when radium has been used rather more in the advanced cases, and in the very old and feeble, we have performed a radical operation in 47 per cent. of the cases examined, radium has been advised in 25 per cent. and a colostomy or no operation done in 28 per cent. Seventeen of the cases were treated by various methods: Perineal excision (Harrison-Cripps), resection and suture, local excision, and excision from above with a permanent colostomy. The number in each group is too small to make them of any particular value. Seven cases have not been traced, and are, therefore, put into the group of those living less than three years. We have, therefore, a series of 268 cases from which the following tables have been made up. In the following tables, the percentages of those living three and five years were obtained after deducting the immediate mortality. It is of interest to note that in at least 5 per cent. of the cases one or more nodules, supposedly metastases, were felt in the liver at the time of operation.

In Table I are given the statistics for all radical operations, both hospital and private cases. The percentages of three- and five-year cases are exclusive of death in the hospital in all the tables.

TABLE I  
*All Radical Operations*

|                           | No. cases | Died in hospital per cent. | Operated three years + | Per cent. living three years | Operated five years | Per cent. living five years |
|---------------------------|-----------|----------------------------|------------------------|------------------------------|---------------------|-----------------------------|
| Private.....              | 136       | 12.5                       | 90                     | 65.5                         | 77                  | 48                          |
| Hospital.....             | 132       | 33                         | 68                     | 66                           | 61                  | 47.5                        |
| Private and Hospital..... | 265       | 22.7                       | 158                    | 66                           | 138                 | 47.8                        |

In Table II are given the mortality and the percentage of cases living three and five years after the combined abdominoperineal operation in one

TABLE II  
*Combined Abdominoperineal Operation—One and Two Stages*

|                         | No. cases | Died in hospital per cent. | Cases operated three years + | Per cent. living | Cases operated five years + | Per cent. living |
|-------------------------|-----------|----------------------------|------------------------------|------------------|-----------------------------|------------------|
| M. G. H. & Private..... | 204       | 22.7                       | 120                          | 70               | 103                         | 50               |
| Private.....            | 102       | 11.7                       | 67                           | 71.6             | 56                          | 53               |

| <i>Combined Abdominoperineal Operation—One Stage</i> |    |     |    |      |    |    |
|--|----|-----|----|------|----|----|
| Private.....   | 54 | 5.5 | 38 | 78.5 | 32 | 56 |

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and two stages and as a comparison the same figures for the combined abdominoperineal operation in one stage done under the best conditions, that is, in private practice. It will be seen that in properly selected cases the mortality in the one-stage operation is not high, and the percentage of three- and five-year cases is considerably higher than by any other operation. This is most gratifying and is conclusive proof, we believe, that the more extensive operation will give better results in those patients who can stand it than in those obtained from more limited operations. These are the statistics which should be compared with those of any other single operation, such as resection and suture, colostomy and posterior excision or any other single operation suggested for removal of cancer of the rectum.

In Table III will be found a comparison of the three important radical operations, the combined abdominoperineal operation in one and two stages

TABLE III  
END RESULTS  
*Abdominoperineal Operation—One Stage*

| No. cases | Died in hospital per cent. | Lived three years + per cent. | Lived five years per cent. | Untraced |
|-----------|----------------------------|-------------------------------|----------------------------|----------|
| 93.....   | 17                         | 73                            | 53                         | 2        |

*Abdominoperineal Operation—Two Stages*

|          |    |    |    |   |
|----------|----|----|----|---|
| 111..... | 27 | 68 | 48 | 4 |
|----------|----|----|----|---|

*Colostomy and Posterior Excision*

|         |      |    |    |   |
|---------|------|----|----|---|
| 61..... | 22.8 | 50 | 40 | 1 |
|---------|------|----|----|---|

*Abdominoperineal Operation in One and Two Stages*

|          |      |    |    |   |
|----------|------|----|----|---|
| 204..... | 22.7 | 70 | 50 | 6 |
|----------|------|----|----|---|

and the colostomy and posterior excision. It will be seen that there is a gradual decrease in the cases living three and five years, from the abdominoperineal operation in one stage to a colostomy and posterior excision which suggests that the more extensive operation gives better results than the posterior excision. This is apparently denied by those who advocate the less extensive type of operation. It would indicate that the more extensive operations should be carried out on those patients who are in sufficiently good condition to withstand the operation.

We are quite agreed with Rankin and some others that the colostomy and posterior excision is the operation of choice for those surgeons who lack experience in selecting proper cases for the more extensive operation. The more experienced the surgeon the more often should he resort to the combined abdominoperineal operation.

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It is interesting to note that forty-three patients who died three or more years after operation died at an average of five years. In sixty-four patients who have lived three or more years and are still living the average duration of life has been seven years. It will, I hope, be seen from these statistics that the radical operation for carcinoma of the rectum has given better results in recent years, and that the operation is well worth the danger and discomfort of it, for we believe that if we can give a patient even one year of comfort the operation has been worth doing. It is evident to all who are doing these operations that if a reasonable amount of interest could be stimulated in the medical profession, operations would be done much earlier, the operative mortality would be lower, and the percentage of five-year cases would be astonishingly high.

DISCUSSION: DR. CARL A. HAMANN, of Cleveland, Ohio, reported his experience with carcinoma of the rectum. Out of a total of 160 cases eighty-three were operable, an operability of 50 per cent. All those that were removed were adenocarcinoma with two exceptions: One a squamous cell epithelioma, and one a melanosarcoma. In only one case was a Kraske's operation done. In only four cases was the coccyx or any portion of it removed.

The youngest in the number was nineteen. The mortality: In eighty-three operations there were fourteen fatalities; the mortality rate was 14.4 per cent. of the operations. There were one Kraske, fourteen combined and sixty-eight perineal operations. No preliminary colostomy was done in any case.

He believed that the psychological effect of an anus in the proper place has a bearing, and he tells a patient that when he gets well his anus will be where it has always been. A great many patients refuse to have an operation when they are told they will have an artificial anus in the iliac region.

The ultimate results were: Of fifty-four patients who were operated on five years or more ago, nineteen are living without recurrence; in other words, there is a five-year cure of 35.2 per cent.

DR. WILLY MEYER, of New York City, remarked that patients who have incomplete obstruction can well be prepared without colostomy if one takes the proper time. It may take six to seven days to get the part above the incomplete stricture clear, at least sufficiently clear, as to give no trouble during the operation. Then one can avoid the preliminary opening.

Regarding sudden complete obstruction, he would mention those seen in former times when the X-ray men still used the bismuth meal. In one case where he did a special kind of cecostomy for the second or third time, the patient had come to the hospital without the symptoms of a complete obstruction. The radiographist gave bismuth from above. The result was complete obstruction. Prompt drainage of the colon by cecostomy was indicated.

Cecostomy with a free opening makes the patient most unhappy. The next better is a cecostomy by the infolding method (Witzel), which makes the

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opening water-tight. He used a special method, which he devised for incomplete colonic obstruction. It is done as follows: Sandbag under right hip; McBurney's gridiron incision; removal of the appendix; an oval area of the cæcum is lined with peritoneum and the centre of the piece of gut, thus placed extraperitoneally, after proper packing with gauze, punctured with a small round cautery. A long rubber tube, prepared beforehand with end and two side holes is immediately introduced. It fills the opening completely and is pushed forward into the ascending colon. It is absolutely water-tight from the start. By daily retrograde irrigation, same as is done in a colonic irrigation from below, the gut is gradually emptied.

He had performed this operation in a number of patients to his entire satisfaction and could recommend it. After a few days the smaller tube is exchanged for a larger one for more voluminous retrograde irrigation. Again, it proves to be perfectly water-tight.

During the following radical combined or straight single operation the anterior abdominal wall is ready for aseptic work, particularly in the middle and left side.

After the operation on the large intestine has been done and healing is complete, the tube is removed. The wound then closes spontaneously just as it does in cecostomy after Witzel's method.

Regarding the patients, he referred to two cases where the growth had developed in a place, which the late von Volkmann called "too low to be operated on from above and too high to be operated on from below." Those are the cases where one has to do the combined method. In both his patients obstruction was incomplete. They were, therefore, prepared as mentioned above, without colostomy or cecostomy.

After tying the inferior mesenteric artery, and having loosened the splenic flexure and descending colon through a left perirectal longitudinal incision, the patient was placed in the knee-elbow posture and the operation finished from below.

It is his opinion that it is best for the patient to save the lower stump of the rectum, wherever possible, even if it is only three or four inches long. In this case, the loosened sigmoid and ascending colon could be easily pulled down and, after proper resection of the gut, the closed proximal end of the descending colon drawn through the rectal stump, which had been deprived of its mucosa, without tension. Today, ten years after the operation, the patient has still perfect continence with normal defecation and no recurrence.

The second case was the same as the first with the exception that the tumor was adhering tightly to the posterior surface of the uterus. He did not dare to do an additional extirpation of the latter. He peeled the tumor slowly off the uterus through the left rectus incision and then did the same operation as before. Here a partial gangrene of the lowest part of the sigmoid which had been placed in front of the anus necessitated the establishment of a sacral anus. With the help of prolonged post-operative X-ray treatment the

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patient is alive and well today, after six years, without recurrence. Both patients were presented before the New York Surgical Society and the cases reported in the Transactions of the same in the *ANNALS OF SURGERY*.

In a third case of incomplete obstruction at the same level a resection of the pelvic colon with end-to-end suture could be done after preliminary cecostomy; done according to the method described. This patient, too, was shown cured before the New York Surgical Society.

DR. WILLIAM L. ESTES, of Bethlehem, Penna., in support of Doctor Verdi's suggestion that many of these cases are not as malignant as they are supposed to be, related an experience with a man who had been thought inoperable. Indeed he appeared to have a perfectly inoperable condition. The middle section of the rectum was thoroughly involved, and he had almost complete stricture with the periphery of the intestine entirely involved by an indurated ulcerative mass. The whole surrounding of the rectum was indurated.

He did a colostomy and after six months, or nearly that, the patient came back. The induration and adhesions, which formerly had held the rectum firmly against the sacrum and the pelvic contents, were entirely relieved and the tumor with the rectal wall could be freely moved. A Kraske operation removed the whole middle section of the rectum. After a year he came back and asked if it wouldn't be possible to get rid of the colostomy. It didn't leak very much and gave him only a little trouble. He did have some odor and occasionally it was more or less disagreeable. An opening was made by the sacral route and the upper part of the rectum was brought down and attached to the lower part. The man lived fifteen years afterward in perfectly good health, and finally died of a retrosacral lymphosarcoma in the right lumbar region; it had nothing to do with the epithelial tissues. Doctor Estes had done this anastomosis in four other cases, all of them from five to nine years ago, and they all had recovered in good condition.

DR. FREDERIC N. G. STARR, of Toronto, Canada, remarked that during the course of 1928, he had seen twelve different people who dated their history of ill health to an attack of what had been called "intestinal flu." Upon examination they all had carcinoma of the rectum, the rectosigmoid or the transverse colon.

During the past few months he had been very much impressed with two cases in which he did a preliminary cecostomy, a procedure which has an advantage if one contemplates restoring the continuity of the bowel, because one has less tension than if there be a colostomy. He also had done the perineal operation, removing the coccyx until the growth was well shown and easily manipulated. Then by placing a barrage of radium needles on each side in the levator muscles and a further barrage of radium needles, platinum covered, directly into the growth and leaving them there for a week he had been much impressed at the rapid retrogression of the growth, although he did not know what the ultimate result would be. This he is sure of, if



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one feels it necessary to remove the tumor later on it will be a much more simple process than it has been in the past.

DR. EMMET RIXFORD, of San Francisco, Cal., reported three cases in which local excision of carcinoma of the rectum was done.

The first case was a middle aged woman, who came with an evident carcinoma in the rectum, about one by two centimetres in size, situated within easy reach of the finger. The finger could pass well beyond it. After dilating the sphincter with the proper speculum, he drew the tumor down and with a transverse elliptical incision cut it out, closing the wound with transverse suture line. The woman is well today and free of recurrence after twelve years with perfect sphincteric control.

Again he did the same thing for a man who was in almost precisely the same condition. The man is now well and free of recurrence after ten years.

In the third case the local operation should perhaps not have been done. The tumor was more extensive—five centimetres in diameter, the man markedly arteriosclerotic. He recovered from the operation, however, but had recurrence. A second excision was done, but patient died in general breakdown, nineteen months after the last operation—probably, though not demonstrably, with further recurrence.

With reference to polyposis and its relation to carcinoma, he could record a somewhat extraordinary family history of a woman whose grandmother had died of carcinoma of the rectum. All of her four children had polyposis and all died of carcinoma of the rectum. In the third generation there were seven individuals, of which his patient was one; four of them had carcinoma of the rectum presumably with polyposis.

He removed the carcinomatous rectum of this woman with part of the sigmoid—fourteen inches of intestine in all because of multiple polypi. Her two sons had polyposis of the rectum. One of them died of pneumonia at the age of twenty-four and polypi were found at autopsy and the other one died of carcinoma of the rectum at the age of twenty-five. Dr. Rixford's patient is alive eighteen years after the excision of the rectum, but her physician reports that she has a palpable tumor in the region of the transverse colon.

DR. FRANZ TOREK of New York City called attention to the rule formulated by Doctor Verdi, that in the presence of metastasis in the liver nothing but a colostomy is indicated.

He, himself, had violated that rule in one case not accidentally but intentionally; a case on which he was operating by the combined abdominal perineal method. When he opened the abdomen he found a metastasis in the liver.

However, the man was suffering very much from the foul discharge from his rectum. Besides, an early extension of his carcinoma to the bladder, prostate, and other pelvic tissues would make him still more miserable while at the present stage the tumor was still extirpable.

He proceeded to operate by the combined method. The patient lived a

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comfortable life for a whole year and then died the rather easy death of a patient with carcinoma of the liver.

It might be worth while to reconsider the question whether the presence of metastasis in the liver should stand as an absolute and inviolable contraindication against resection of the rectum for carcinoma as long as the tumor itself is still thoroughly removable.

Another point, brought up by Doctor Jones' paper, is the opinion, shared by so many surgeons as to make it appear almost as an axiomatic truth, that if the resection of a patient's rectum involves also the extirpation of his sphincter, he is in a deplorable condition with the perineal anus. That had not been his experience. The important thing is just exactly what Doctor Jones has told in reference to the colostomy wound, that the patient gets along with it very well provided he is instructed to manage it in the proper way, and provided he is kept constipated. If that same rule is followed in the case of a perineal anus the patient will get along just as well.

He had had a number of these cases and if the patient follows the instruction to take a thorough enema every morning, clearing out his rectum and sigmoid, he is free from trouble for the rest of the day.

DR. LEWIS L. McARTHUR of Chicago, Ill., endorsed the recommendation of Doctor Verdi that the abdominal incision should be made for the opportunity it gives to determine metastasis, local or elsewhere. If one finds, with the abdomen open—and it is unfortunately true that we do often find—the mesenteric glands in front of the promontory invaded, or in the hollow of the sacrum or nodules in the liver, he should—except in some individual cases where the offensive condition obtains locally—decline to make an extirpation of the tumor, but then and there decide whether the artificial anus shall be permanent or temporary. He related two illustrative cases: One was a case of carcinoma of the rectum requiring exploration first. It required the making of a temporary artificial anus, then the removal of the carcinoma, which could be reached rectally with the finger in the hollow of the sacrum, taking off the coccyx and only a very small portion of the left side of the sacrum.

It was possible to make this excision of the rectum after two weeks from the time of the colostomy. Meanwhile a remarkable effect had resulted from irrigations of the lower segment of the bowel, through the artificial anus, with mercurochrome twice a day. Having resected the tumor and loosened up the bowel above, it was possible to whip the two ends of the bowel together in order to hold them in the position in which future union should be made, the sphincter muscles being preserved. An absolutely primary union was obtained because the bowel, presumably, was absolutely sterile after two weeks of irrigation with 1 per cent. mercurochrome. He had never seen it in any other operation in which a single suture of the bowel has been obtained. Having gotten that union, three weeks afterward the artificial opening was closed and that man is in perfect health. This is the fourth

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year since it was done, showing that one can frequently preserve the lower segment.

In a similar case in which the artificial anus was made, and no irrigation done, it was impossible to bring the ends together and the upper proximal end was turned in with a silk suture for permanent occlusion, thereby making the artificial anus a permanent one. The upper end of the distal segment was closed with a silk suture and the man abandoned to an artificial anus. After a very stormy convalescence the silk sutures sloughed out and the artificial anus sank in as it does occasionally after the Maydl operation. The patient began passing his faeces through the natural channels after both ends had been closed for permanent closure. He is living and well six years after the operation.

DR. J. SHELTON HORSLEY of Richmond, Va., remarked that one objection frequently offered to the combined abdominal perineal method is that there is much shock. All agree that if a block dissection of cancer can be completed in one stage, other things being equal, it is much more desirable than having two stages. The object of the second stage in carcinoma of the rectum, unlike the two stages when there is obstruction of the colon, is not so much to avoid obstruction as it is to avoid death from shock.

If one anticipates this one can start in at the beginning of the operation with a continuous intravenous glucose and Ringer solution and it can be watched by the anæsthetizer or by a nurse and the flow increased or diminished so as to keep the blood pressure and pulse rated at a satisfactory level. Frequently these patients can be carried through a prolonged operation not permitting them to get into the preliminary stages of shock. If, in spite of that, shock comes, a donor should be waiting and transfusion done at once.

By this method a prolonged procedure can be carried on and the operation completed at one stage.

In regard to the cases reported by Doctor Rixford, unfortunately the speaker had had experience that is quite the reverse of his. In a patient on whom, about four years ago, a local operation for carcinoma of the rectum was done, the operation was comparatively easily done. The carcinoma was not of a high grade of malignancy. She returned a few months later with extensive anal recurrence. If a radical operation had been done in the first stage that patient would probably be alive today. Here was a mistaken judgment and an error in doing a local operation on a patient on whom a radical operation should have been done.

While, of course, an artificial anus is not desirable it is much more desirable than death. An abdominal artificial anus is not the extremely objectionable thing that some patients contend. It is better to have an artificial anus that can be kept clean than to have a sentimental perineal anus that cannot be kept clean.

DR. HERBERT ALEXANDER BRUCE of Toronto, Canada, spoke of the treatment of inoperable cases by radium. Last year, while attending the International Congress on Cancer in London, he saw a number of cases with Sir

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Charles Gordon Watson who had been using the method practiced by Neumann of Brussels in inoperable cancer of the rectum, which consists in exposing the growth by operation just as if intending to remove it, and then inserting the radium into the growth as well as along the lymphatic spread.

In some cases of inoperable cancer of the rectum, in which he had attached the sigmoid to the abdominal wall ready for a colostomy later because obstruction already existed, the radium embedded in the growth was so effective that the obstruction was relieved in the course of a week or ten days, and it was not necessary to complete the colostomy.

The results obtained from the use of radium in inoperable cases are so good that one feels justified in employing it rather than condemning the patient to a permanent colostomy.

Secondly, in cases where the growth is attached in front to the uterus, the vagina or the prostate, and where it seems clearly inoperable, the use of radium will make it possible later on to remove these growths by surgery.

Thirdly, in cases of carcinoma of the anus, which is a squamous-celled carcinoma, he reported excellent results from radium alone.

DR. WILLIAM F. VERDI (in closing the discussion) remarked that in any case of cancer of the rectum a preliminary colostomy is a marvelous help.

One of the gentlemen has already spoken of the fact that the possibilities of improvement after this procedure are great. With a colostomy established one can wash out the frightfully infected rectum. In every case of carcinoma of the rectum that he had seen the tumors were large, fungoid, and sloughing blood, pus, mucus and necrotic tissue. If one can get that condition cleaned up one is surprised to see how much one can do afterward.

He was in favor of radical operation for cancer. He would go as far as possible with any form of cancer, but cancer of the rectum is an entirely different type of cancer. The glandular distributions of the rectum are not like they are in cancer of the breast, or cancer of the neck, or cancer of any place where there are definite channels and glands draining the structure that one is about to remove. The network of lymphatics in the pelvis all intertwine between the uterus and bladder and rectum so that it really is difficult to do a radical resection in the pelvis for cancer.

## THE SURGERY OF MEDIASTINAL DERMoids

BASED UPON AN EXPERIENCE WITH FOUR CASES AND A REVIEW  
OF THE LITERATURE

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OF CINCINNATI, OHIO

It is rather venturesome to discuss the surgery of mediastinal dermoids on the basis of only four cases; but a review of the literature would indicate that in this small series I have met most of the complicating conditions associated with dermoids, such as infection, calcification, hæmorrhage, and communication with a large bronchus; complications which have raised questions as to the proper approach to the lesion, the proper treatment of the lesion when exposed, and the proper method of closure. So, too, I have had some of the post-operative complications which others have experienced, and which in one case led to a fatality which in retrospect might well have been avoided. As a result of my experiences and a review of the literature, I propose in this paper to discuss three aspects of the surgery of mediastinal dermoids: (1) The surgical approach to the lesion; (2) the treatment of the lesion when exposed, and (3) the method of closure of the thoracic wound. I shall discuss these three questions in connection with a report of my four cases.

**CASE I.**—The patient, a colored laborer, fifty-three years of age, entered the Johns Hopkins Hospital October 12, 1916. He complained of cough, pain in the right side, and shortness of breath. His family history was unimportant. He had had typhoid fever and pneumonia involving the left lung thirty-two years before; a Neisser infection and a genital lesion thirty years ago, but not followed by secondary or tertiary luetic manifestations; and a perforation of his nasal septum, the result of his occupation in an acid factory fifteen years ago. With the exception of pneumonia, he gave on admission no history of symptoms referable to his respiratory tract previous to the onset of his present illness. Questioned since his recovery from operation, however, he states that he now realizes that he had some "misery" in his side and shortness of breath on exertion for an indefinite period. He had been married twice. His first wife died of tuberculosis at the age of thirty-eight. His second wife died two years ago of cancer of the stomach.

**Present Illness.**—One morning, four weeks before admission, while shifting bags of fertilizer, each weighing 300 pounds, he had a sudden severe pain in the right side of his chest, with cough and shortness of breath. The symptoms were so severe that he was compelled to stop work, but was able to walk to a doctor's office. The physician advised rest in bed, and he remained in bed until his admission to the hospital. The cough persisted while the pain and shortness of breath were less troublesome when he was lying quietly in bed.

**Physical Examination.**—He was a very large, well-nourished, muscular man, apparently not seriously ill. The general physical examination, with the exception of that pertaining to his right thorax, was entirely negative. His temperature during the period he was under observation varied between normal and 100°, with an almost daily rise in the afternoon to 99° or 99.2°.



## THE SURGERY OF MEDIASTINAL DERMoids

The right side of the chest on inspection was somewhat flattened over the right upper front. There was diminution in expansion of the entire right side. Vocal fremitus was moderately increased about the apical region in front and behind. It was diminished, but still present, over the lower axillary and subscapular regions. The percussion note and resistance were distinctly increased above the clavicle and over the supraspinous fossa. With the patient in the erect position, flatness began at the upper margin of the fifth rib, and in the recumbent position, in the middle of the sixth interspace. Behind, the flatness began at the level of the angle of the scapula, and continued downward. Beginning just below the level of the line of flatness on the right side there was at least a suggestion of a Grocco's sign on the left. On auscultation the breath sounds were enfeebled at the apex in front and behind. There was an occasional fine bubbling râle on inspiration. Below the line of flatness in front and behind the breath and voice sounds were enfeebled and the vocal resonance was diminished. No pleuritic friction rub was audible.

The patient was repeatedly examined by various members of the medical staff, and in general the above findings were corroborated. The diagnosis on physical examination alone was a right-sided pleurisy with effusion, of uncertain origin. A thoracentesis was attempted before a roentgenogram had been made. The exploring needle introduced at the eighth interspace behind met with a firm unyielding resistance. No attempt was made to force the needle beyond the obstruction. The procedure resulted in a "dry tap."

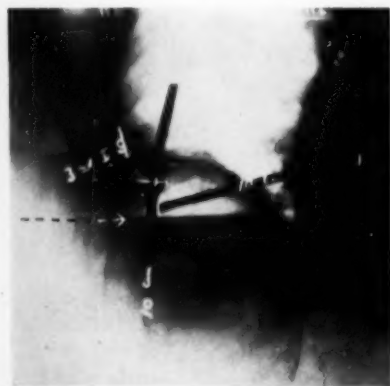


FIG. 2.—X-ray of thorax of Case I, in erect position. The fluid level within the cyst is indicated by the arrow.

upward into the thoracic cavity. Mesially, the structure was in contact with the mediastinum, laterally it approached to within about one centimetre of the rib margin. The wall of the structure varied from one to 2.5 millimetres in thickness. (Fig. 1.) With the patient prone, the contents of this apparently cystic structure cast a shadow of uniform density. In an erect position they separated into two layers, a lower, consisting of fluid and casting a definite shadow; and an upper, consisting of air and represented by an absence of shadow. (Fig. 2.)



FIG. 1.—X-ray of thorax of Case I, showing outline of calcified cyst. Recumbent position. The outline of the cyst has been accentuated.

*Röntgenological Examination.*—Röntgenograms of the chest explained the cause of the obstruction of the exploring needle and were of the greatest aid in the diagnosis of the condition. The roentgenograms showed in the right thoracic cavity a perfectly circumscribed shadow with remarkably clear outlines. This shadow in general was pyramidal in shape, its base was flattened and rested upon the diaphragm, its apex was rounded and extended 11.5 centimetres

Close examination of the wall of the structure showed apparently a crack at its upper outer pole. Examined stereoscopically the mass appeared to lie nearer the anterior thoracic wall than the posterior.

*Laboratory Findings.*—Red blood cells 3,552,000, hæmoglobin 60 per cent., white blood cells 7240. Differential count: polymorphonuclears 66 per cent., eosinophiles 0.3 per cent., basophiles 0.3 per cent., small mononuclears 13 per cent., large mononuclears 14 per cent., transitionals 6.3 per cent. Wassermann reaction (blood and spinal fluid) was negative. Urine examination showed no abnormalities. Sputum, the daily amount varied. On some occasions during paroxysms of coughing the patient expectorated a cupful of yellowish or reddish-brown seropurulent sputum. It had a slightly foul odor and contained numerous cholesterin crystals, numerous pus and epithelial cells, a few red blood corpuscles, many irregular large and small granular cells containing black pigment dots, and an occasional unidentified structure twenty micra in diameter which when stained proved to be an organism containing an ectosarc and an endosarc and provided with a unipolar group of cilia. Repeated search and digestion studies failed to show hooklets. Hairs were never found and tubercle bacilli could not be demonstrated.

*Summary and Discussion.*—The patient was a man of fifty-three years, who, up to the day of onset of illness, had performed the heaviest labor and was unaware of the condition in his chest until a physical strain gave rise to pain, cough and shortness of breath. He presented the physical signs of pleurisy with effusion. In an attempt to confirm the diagnosis by thoracentesis, the exploratory needle met with resistance such as might be offered by a bony structure. The röntgenograms made possible a diagnosis which could not have been reached by physical examination alone. From these it was evident that there was present a cystic condition with almost complete calcification of the cyst wall, and that the cyst contents consisted of fluid and air. That there was a communication between the cyst and the lung was clinically evident because of the periodic expectoration of large amounts of sputum. The röntgenogram apparently showed this point of communication. Following the röntgenological studies, diagnostic efforts were directed toward establishing the nature of the cystic condition. There was no evidence of tuberculosis, no eosinophilia and no characteristic findings in the sputum, such as hooklets or hairs. Etiologically, there was no history of pulmonary affections, of trauma of the chest or of intimate association with dogs. A positive diagnosis could not be made. The diagnoses suggested were dermoid cyst, encapsulated empyema, hæmatoma of the thorax, and echinococcus cyst.

*Operation.*—November 8, 1916. Under ether anæsthesia, through a long incision, about twenty centimetres of the ninth rib were excised. The parietal pleura was stripped away from the thoracic wall so as to allow satisfactory inspection and palpation of the lesion before opening the pleural cavity. On palpation through the detached pleura, it was at once evident that an extremely hard mass lay directly underneath and was firmly attached to it. A horizontal incision was made through the parietal pleura and the exposed portion of the mass examined. Its presenting surface was whitish in color and of bony hardness. An attempt was made to find a layer of cleavage between it and the parietal pleura, but this was entirely absent over its lateral and anterior aspects. It was necessary to cut across the adhesions with scissors and knife, and after this had been done for a considerable distance in all directions, the anterolateral surface of the cyst was largely exposed.

The operator was a little doubtful how to continue, but having begun to enucleate the mass he kept on with this procedure. As previously noted, it was necessary to cut between the adherent pleura and the outer wall of the mass over its entire anterolateral aspect. Having freed this surface, the operator next explored that in contact with the diaphragm. Here the adhesions became less dense, so that it was easily possible to strip away the diaphragm from the inferior surface of the mass. The operator then explored the mesial wall of the cyst, and found dense adhesions between it and the anterior mediastinum. These were cut with knife or scissors until this aspect of the

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mass was freed. Unfortunately, at the lower mesial aspect of the cyst the operator penetrated its wall, and there followed a discharge of a small amount of a thin, yellowish, purulent material and some air bubbles. The operator packed some gauze into this opening and temporarily left this region. Inserting his hand between the inferior aspect of the mass and the diaphragm, he found the posterior and posteromesial surfaces of the structure could be stripped away from the overlying lung with remarkable ease, so that in a few moments this region was freed from what subsequently proved to be the concave surface of the lower lobe of the lung. The operator then proceeded to free the lateral aspect of the cyst which also was densely adherent to the parietal pleura. The freeing of the upper pole of the mass gave especial trouble, and before this was accomplished it seemed necessary to enlarge the operative field by the resection of about fifteen centimetres of the eighth rib.

A narrow strip of lung tissue adherent to the upper pole was cut across and left upon the cyst wall. While freeing this part of the mass there occurred a spontaneous escape of a small quantity of cyst contents and air bubbles, and it was assumed that the communication between the cyst and lung was at this point. The last step in the enucleation of the mass was the freeing of its mesial and anterior walls from the mediastinum. It was found that here the bony shell was not complete but was in part formed of dense fibrous tissue. By its division the cyst was opened widely and the major part of its contents escaped. The shell was finally removed *in toto*. There was no hæmorrhage through the entire procedure; indeed, it was not necessary to tie a single blood vessel.



FIG. 3.—Final result in Case I, showing the well-healed encircling incision.

After the removal of the mass a very large cavity remained, the inferior surface of which was formed by the diaphragm, the mesial surface by the mediastinum, the upper and posterior surface by the concave surface of the lower lobe of the lung, and the anterolateral surface by the thoracic wall. The right side of the heart lay under the mesial surface of the mass. It was noted that the visceral pleura of the lung in contact with the mass was not thickened. No attempt was made to obliterate the large cavity left after the removal of the mass. It was drained with a single rubber tube. The wound was closed in layers.

*Post-operative History.*—The patient left the operating table in good condition. There were no post-operative complications other than a slight wound infection. For three days the temperature varied between  $99.5^{\circ}$  and  $100.2^{\circ}$  and then came to normal. Bismuth injections showed a rapid obliteration of the cavity in the right thorax. By March 1, 1917, the cavity was entirely obliterated, the wound healed and the patient apparently perfectly well. (Fig. 3.)

*Pathological Notes.*—The calcified mass lay within the pleural cavity, not within the lung. The specimen consists of a roughly pyramidal calcified shell which measures



FIG. 4.—Photograph of specimen of calcified cyst in Case I. Anterolateral aspect.

thirteen centimetres in its greatest horizontal diameter, 11.5 centimetres in its greatest vertical height, and seven centimetres in its anteroposterior diameter. (Fig. 4.) Its inferior surface, which rests upon the diaphragm, is flattened and slopes slightly upward and backward; its anterior surface is slightly flattened, while its upper and posterior surfaces are quite spherical. Its wall is complete with the exception of a roughly circular defect about four centimetres in diameter. (Fig. 5.) The anterolateral surface of the shell is roughened and covered by dense fibrous tissue while its apex and posterior curved aspect are perfectly smooth. On examination it is quite evident that the entire shell, with the exception of the defect previously noted, is made up of calcified tissue measuring one to two millimetres in thickness. Its inner surface is roughened and covered by a soft putty-like sediment two to three millimetres in thickness. Microscopic sections show that this sediment is made up of detritus in which no structure which

might give a clue to the nature of the condition can be found. Sections of the wall of the cyst show calcification and not new bone formation.

Studies of the cyst contents and of the sediment failed to establish the nature of the condition, but the presence of cholesterol crystals and cellular detritus strongly suggest a dermoid cyst.

*Discussion.*—Reviewing our own experience, this, from the standpoints of a simple direct approach, of complete removal of the lesion, of satisfactory closure and of short convalescence without deformity at the end, is our most ideal case and one of comparatively few in the literature. In discussing the proper surgical approach to mediastinal dermoids, two groups of cases must be considered, the uncomplicated dermoids and the dermoids complicated by infection. Dermoid cysts may vary greatly in size and may occupy a variety of positions. Duval has conveniently classified them according to their location into: (a) Retrosternal, those not extending beyond the confines of the mediastinum; (b) cervico-retrosternal, those presenting at the base of the neck, in or to one side



FIG. 5.—Mediastinal aspect of calcified cyst in Case I, showing the defect in the cyst wall. It was here that the cyst was attached to the pericardium.



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of the suprasternal notch; (c) mediastinothoracic, those extending beyond the confines of the mediastinum into either thoracic cavity; and (d) lateral thoracic, those lying largely in either half of the thorax. The uncomplicated dermoids—and by those I mean dermoids without historical or clinical evidence of infectious complications or communication with a large bronchus—may occupy any one of these positions and the proper approach will, therefore, depend upon the size and location of the tumor. A great number of surgical approaches have been described and used which, perhaps, I may briefly outline and comment upon.

1. In the cervico-retrosternal cysts—those small dermoids which lie behind the sternum but project upward into the neck—a simple cervical incision, as in the goitre operation, may suffice. The procedure is carried out as in substernal or intrathoracic goitre. Five cases in the literature have been successfully approached in this way; in four with total enucleation of the cyst and in one with partial enucleation. In the larger tumors in this location the cervical approach may be combined with resection or division of the upper portion of the sternum, according to the technic of Bardenheuer or Sauerbruch.

2. In the larger retrosternal or mediastino-thoracic tumors a great variety of approaches have been used which roughly may be grouped as follows: (a) A single, long, intercostal incision, or one with the resection of a single rib placed at a proper level and exposure obtained by a powerful rib spreader; (b) trapdoor approaches of various sorts with pedicles internal, external, superior or inferior; and the object of which is to produce a wide exposure of the thoracic contents which can again be covered by the replacement of the flap. To this group belongs the more recent approach of Kerr who, however, includes a section of the sternum in the trapdoor; (c) multiple resections of ribs so as to produce a large defect in the thoracic wall through which the tumor may be delivered. This has been the most common method of approach to the larger dermoids. (d) Various forms of sternotomy or division of the sternum, the exposure being obtained by separating the edges of the divided sternum with a rib spreader. These include transverse sternotomy, median and vertical sternotomy, which may be partial and superior or inferior, according to the location of the tumor; or total median sternotomy as first proposed by Milton, and later suggested by Auroousseau; and (e) The Tuffier-LeFort approach to the mediastinum which I used in cases III and IV of the following series.

3. In the large lateral thoracic tumors, approaches similar to the preceding groups have been used; but because of the size and the location of the lesions have been restricted to the long intercostal incision or the resection of a single rib, to trapdoor approaches and to multiple rib resections.

To attempt to evaluate all these surgical approaches on the basis of our small experience is difficult; but a consideration of the literature helps us in formulating an opinion. Moreover, the same principles underlying the approach to intrathoracic tumors in general apply to mediastinal dermoids and



in this field we have had a fairly large experience. Certain observations have come from this experience, (a) that air-tight closure of a thoracic wound is highly desirable and even essential; (b) that post-operative infection occasionally occurs following the removal of uncomplicated dermoids as well as other intrathoracic tumors (it occurred in our only uncomplicated case); and (c) that post-operative pleural effusion is a common accompaniment of the removal of intrathoracic tumors, and may become secondarily infected with the development of an empyema. Tension pneumothorax, open, sucking chest wounds and mediastinal and intrapleural infections may, therefore, follow the removal of intrathoracic tumors. From the viewpoints of avoiding or coping successfully with these complications, the approach to the tumor through a long, intercostal incision or one combined with the resection of a single rib is far superior to all the trapdoor approaches, the multiple resections of ribs, the various operations involving the sternum and the approach of Tuffier and LeFort. The points in its favor are that it can be securely and air-tightly closed and it interferes least with the bony framework of the thorax. In our own experience the tumor in Case I was approached through this incision and from the standpoints of exposure of the lesion, closure of the wound, and post-operative complications was the most successful of the series. Cases III and IV, as will be subsequently detailed, were approached through the incision of Tuffier and LeFort, which consists in the resection anteriorly of a single rib with the division near the sternum of the rib cartilages above and below. In one the exposure was difficult and unsatisfactory, in the other very satisfactory. In one a post-operative infection occurred, the wound reopened and a mediastinitis and empyema developed. By good fortune the patient recovered, but the convalescence was greatly prolonged. But had we not avoided in this case the opening of the pleura during the operation, an open, sucking chest wound would have resulted with the almost certain death of the patient. In similar complications when an intercostal incision is used the intrathoracic infection may be drained by means of air-tight suction drainage at some distance from the original incision, with the result that this may heal per primam and the condition resolve itself into the treatment of a simple, closed empyema. We have had this experience. When we review the literature we find many experiences similar to our own. Post-operative infection has been common following the removal of dermoid cysts, presumably due either to errors in technic or to opening what was thought to be an uninfected cyst, or to draining or packing the cavity left after the removal of the cyst. The method of approach has greatly altered the results in the presence of these complications. It has led to death in a number of cases; if not that, has been responsible for a prolonged convalescence with one to many subsequent thoracoplastic procedures to collapse a large infected cavity; or to repeated operations for chondritis or osteomyelitis of divided ribs or sternum. The end result has been a collapsed chest with its unsightly deformity and impaired function. In the literature

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as well as in our own experience a higher percentage of satisfactory results have been obtained with the intercostal incision.

We would suggest, therefore, that in the approach to uncomplicated dermoids the simple collar incision be used in the small cervico-retrosternal tumors and that the long intercostal incision, or as we like better, the resection of a single rib, be used in the approach to the larger mediastino-thoracic and lateral thoracic tumors whenever possible. Closure should always be securely air-tight and without drainage. In the absence of infections, convalescence is a matter of two weeks with a perfect cosmetic and physiological result; if infection should occur, the problem of treating it is simplified and with the possibility of as satisfactory a result as in acute empyema. In contradistinction the various trapdoor approaches, multiple rib resections, etc., are satisfactory only in the absence of complicating conditions; when such complicating conditions occur, especially infection, they become most unsatisfactory.

The proper treatment of the dermoid when exposed, both from the standpoint of immediate and remote cures and of the avoidance of post-operative complications requires but little discussion. In the treatment of our four cases we invariably made the effort to totally remove the lesion; but we succeeded in only two and failed in two. In one case (infected teratoma) we failed to totally remove the lesion because we could not separate a part of it from the pericardium and feared to persist in the effort because of the danger of pericarditis. In the other case we failed because of the combination of the unusual position of the lesion and the poor exposure. There can be no doubt that radical removal of the tumor is desirable. In a search of the literature and including the four cases above, I have found 138 cases of dermoid cyst of the mediastinum reported. Of these twelve were found at an autopsy in persons dying without the lesion having been diagnosed; eight were diagnosed more or less definitely but the treatment, if any, and the end results are not known; forty-six died untreated and in the majority of cases the diagnosis was established post-mortem, and seventy-two were subjected to operation. Of the seventy-two cases subjected to operation one was treated by simple drainage of the pleural cavity; thirty-four by incision and drainage of the dermoid cyst sometimes with marsupialization; thirteen by incomplete extirpation of the tumor and twenty-four by complete extirpation of the tumor. Of the thirty-four cases treated by incision and drainage nine died within two weeks after operation; four recovered for a time but died as a result of the condition from several weeks to several years after operation; eight recovered but at the time of the last report had persistent fistulas; one recovered but was unimproved, the lesion remaining as before; 5 were cured for from a short period to several years; five recovered but the end result is not stated; and in two cases the outcome of the operation is not given. Of the thirty-four cases, therefore, only five are known to have been completely cured. Of the thirteen cases which died some time after operation

death resulted from sepsis, hæmorrhage or some other complication attributed to the lesion.

Of the thirteen cases treated by *incomplete extirpation* of the lesion two died and one was rapidly going down hill from sepsis at the time of the report; four recovered but with draining sinuses; five recovered and were cured from a short time to four years; and one recovered but the end result is not known. In this group pre- and post-operative infections were common; and multiple operations (in one case ten operations) were the rule. Of the twenty-four cases treated by *complete extirpation*, three died and twenty-one recovered. The twenty-one which recovered were cured.

It is evident from this review that complete extirpation, both from the standpoints of mortality and late results, has yielded by far the best results and is the proper treatment whenever possible. Naturally this procedure applies particularly to the uncomplicated dermoids and unquestionably the

fact that they were uncomplicated has been responsible in a large measure for the favorable results obtained. When we review the entire series of seventy-two cases subjected to operation we find that twenty-one are known to have died and the majority of these died from infectious complications; a few from hæmorrhage and other complications. It is this fact which has called forth our remarks upon the treatment of infectious complications and methods of approach.



FIG. 6.—Photograph of thorax in Case II, showing the anterior discharging sinuses.

CASE II.—A. B., white, female, thirty-nine years of age, was admitted to the Cincinnati General Hospital October 20, 1925, complaining of an intrathoracic tumor and draining sinuses in her neck and right thorax. Early in December, 1921, she developed acute tonsillitis with quite a high fever. About the middle of this month she noticed a small lump or swelling at the base of the neck to the right of the episternal notch, but mesial to the sternomastoid muscle. This area felt rather tense and there was local tenderness. She also had a dull pain in the right apical region of the chest. There was no difficulty in swallowing. There was no cough or expectoration. On January 5, 1922, this swelling, having become more acutely tender, was incised by a physician and a thick, rather cheesy, grayish material, with some hair, was evacuated. Following the drainage of this evident dermoid there was considerable fever so that the patient was compelled to remain in bed. She was ill for some time with fever and pain in her chest, and with considerable loss in weight. A diagnosis of right-sided empyema was made, and on February 22 a rib or ribs were resected just to the right of the sternum. The pleura was opened and pus obtained, which on examination also contained cheesy material and hair. At the same time a rib was resected rather low in the posterior-axillary line upon the right side and pus also obtained here. Drainage tubes were placed through both wounds and following this procedure the patient slowly recovered. Eventually the anterior drainage opening closed. The sinuses in the neck and in the lateral region of the right thorax have continued to drain. She was confined to bed for eight months and her weight dropped to eighty pounds. In November,

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1922, she went to Baltimore and was given one radium treatment at Dr. Howard Kelly's Hospital. Between that time and the time of her admission in October, 1925, she had gained in weight and her general condition had improved. The sinuses in her neck and her side have, however, never healed.

*Physical examination* showed a rather undernourished woman, weighing 115 pounds, with a draining sinus at the root of the neck to the right of the mid-line, and another draining sinus in the right thorax posteriorly. There was a healed scar on the anterior aspect of the right chest just to the right of the sternum. (Figs. 6, 7 and 8.) Examination of the thorax showed the left chest larger than the right with limitation of expansion on the right. The percussion note was markedly impaired over the anterior aspect of the right thorax. Vocal fremitus was

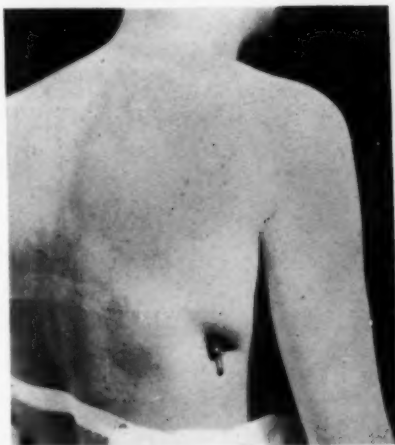


FIG. 7.—Photograph of thorax in Case II, showing the sinus of a chronic empyema.



FIG. 8.—Photograph of hand in Case II, showing clubbing of the fingers.

diminished and the breath sounds were distant. Posteriorly over the right chest the percussion note was much less impaired and the breath sounds nearly normal. No rales were heard on either side of the chest.

In the episternal notch to the right of the mid-line and just medial to the right sternomastoid muscle was a discharging sinus with a ring of granulation tissue about it. This sinus admitted a rubber tube eight millimeters in diameter, which passed down the back of posterior to the clavicle into the right thorax for about two inches. A yellowish-gray, creamy pus exuded from this sinus. Just to the right of the sternum, extending from the third rib down to the level of the lower margin of the sternum was a depressed area, 2.5 centimetres wide, in which there was a healed scar. Laterally on the

right of the chest low in the posterior-axillary line was another draining sinus which led into the thorax and which also was discharging a thick pus. X-rays of the chest showed a very large mass occupying the anterior mediastinum, extending to either side of the mid-line, but larger upon the right than the left, which fused with the cardiac shadow. (Fig. 9.) Lipiodal injections into the sinuses of the neck and thorax showed a chronic, right-sided empyemic cavity lying in the lower part of the chest. This cavity communicated with what apparently were multiple abscesses within the thoracic tumor. The abscesses within the tumor also connected with the draining sinus in the neck. (Fig. 10.) The diagnosis in view of the history of the discharge of hairs, and in view of the X-ray pictures, was infected dermoid of the mediastinum associated with a chronic empyema and a discharging sinus of the neck.



FIG. 9.—X-ray of the thorax of Case II, on admission, showing the large mediastinal shadow. A part of the clouding of the right thorax is due to the thickened pleura, the result of the chronic empyema.



*Course.*—As a preliminary step in the treatment, tubes were introduced into the sinus of the neck and into the empyemic cavity and Carrel-Dakin treatment begun. It seemed desirable to control the infection before making an attempt to remove the



FIG. 10.—X-ray of the thorax of Case II, following a period of Carrel-Dakin treatment of the chronic empyema and after the injection of lipiodol into the external sinuses. The abscesses within the teratoma are shown by the local collections of lipiodol.

mediastinal tumor. Our purpose was to attempt to isolate the tumor from the right thoracic cavity so as to clear up the chronic empyema and to heal, if possible, the sinus in the neck. With this idea in mind, after a period of irrigation, the first step in the operative procedure was carried out, October 1, 1925. A vertical incision was made along the right border of the sternum from a point just below the clavicle to a point just below the inferior end of the sternum. From the upper and lower ends of the incision, counter incisions were carried outward across the chest. A skin muscle flap, including the pectoralis major, was turned outward so as to expose the right border of the sternum and the costal cartilages. The costal cartilages of the second, third, fourth and fifth ribs were resected, in the course of which procedure one of the

branches of the internal mammary artery required ligation. (Fig. 11.) After the resection of these cartilages one could immediately palpate a very firm, solid tumor. After penetrating what appeared to the operator to be the thick, parietal pleura, he was able, by blunt dissection, to outline in part the lateral and inferior borders of the tumor mass. The mass was found to be of great size extending from the clavicle to the lower end of the sternum. It seemed unwise because of the infection and the dense adhesions to attempt at this first stage a removal of the tumor, and the operator determined, therefore, to isolate the tumor from the general pleural cavity on the right and to isolate it from its connection with the sinus in the neck. Therefore he continued to explore and free the right lateral border of the growth until he came upon the connection of the tumor with the chronic empyemic cavity. At this point there was an abscess in the tumor mass containing about an ounce of pus which was evidently draining into the chronic empyemic cavity. This abscess was evacuated and into it was inserted a cigarette drain which was brought forward around the lateral border of the growth. The operator then directed his attention to the superior pole of the tumor which apparently connected with the sinus of the neck.

Having quite satisfactorily surrounded the superior pole of the tumor an incision was made directly across it and there was found a cavity filled with sebaceous and purulent material which connected with the sinus in the neck. In cutting across the superior pole the operator encountered pieces of cartilage and bone and it became at once apparent that he was dealing with a teratoma and not a dermoid. Having cut cross the superior pole of the tumor it was possible to bring a drain through the sinus in the neck to the remains of the cavity left after the resection of the upper pole of the mass.

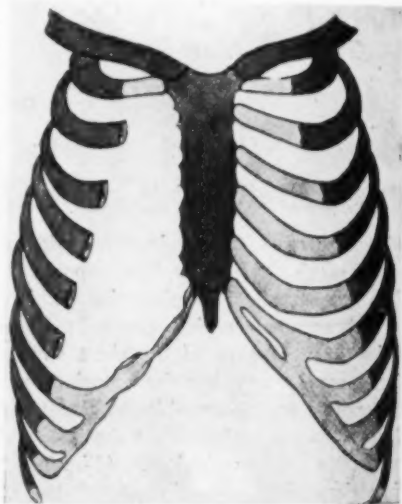


FIG. 11.—Method of approach to the infected teratoma in Case II.



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As a final step in this first stage the lateral border of the tumor was sutured to the parietal pleura. The skin was partly closed.

The patient recovered satisfactorily from this operation and for a period of several months the chronic empyema cavity was treated by the Carrel-Dakin method as was also the sinus in the neck. Eventually the chronic empyema cavity was completely obliterated and the thoracic sinus closed, as was also the sinus in the neck. The patient, meanwhile, was treated by heliotherapy and gained greatly in weight and strength. As a result, then, of this first stage in the operation we had cured the chronic empyema and had healed the connection between the tumor and the tissues of the neck.

On April 19, 1926, a second stage in the removal of the tumor was undertaken. The old operative scar was excised and the right lateral half of the sternum from the sternoclavicular joint to the xiphoid was rongeured away exposing the medial border of the tumor. An attempt was then made to surround the tumor by blunt dissection. During this manœuvre several large, bleeding vessels were met with, but were clamped and ligated without any serious loss of blood. The mobilization of the tumor was apparently completed excepting for an area at its lower mesial portion where it was most firmly attached to the pericardium and the great vessels. During our manipulation in this region the patient's condition rather suddenly became precarious, her pulse became very rapid, and she became quite cyanotic. The operation was abandoned, the

wound being brought together and loosely closed with silk, and the patient given a blood transfusion on the operating table. She made a very prompt recovery and her convalescence proceeded without event. Ten days later the patient was once more operated upon. The wound was reopened and an attempt made to free that portion of the teratoma attached to the pericardium and great vessels. This effort finally was abandoned because it seemed impossible of accomplishment. Moreover, another small abscess within the tumor was opened which might well have caused a pericarditis did we inadvertently open the pericardium. The operator had to be content with carrying an incision through the tumor tissue leaving a layer of the tumor of indefinite thickness attached to the pericardium and great vessels. In the course of sectioning the tumor various structures were encountered, one of which was a piece of bone of the general



FIG. 12.—Result in Case II at the time of the patient's discharge from the hospital. The wound has since closed to a small sinus.

shape of a mandible with several teeth and some hair attached. At the completion of the operation it appeared that practically all the tumor had been removed excepting that portion along the pericardium and great vessels. The wound was closed with drainage. At the completion of the operation the patient was given another transfusion of 500 cubic centimetres of blood. Following this procedure the patient again made a very satisfactory recovery and her wound healed fairly rapidly. There developed subsequently, however, a local chondritis about the resected ends of two costal cartilages so that on two subsequent occasions a small operative procedure consisting in the resection and drainage of the infected cartilages was done. The patient was finally discharged with her wound not quite healed. There remained a cavity which led to the tumor tissue along the mediastinum which as time went on became covered with a grayish-white epithelium. With the exception of this small, unhealed area the patient is at the present time, May 1, 1929, perfectly well and has no complaints. She has gained some fifty pounds in weight. Figure 12 shows the present condition.

The examination of the tumor removed shows a typical teratoma. Here and there on section it contains small abscesses as shown in the X-ray plates following lipiodal injections.

*Discussion.*—From a survey of the literature the common complicating conditions present at the time the patient has come under observation have been hæmorrhage and infections of various sorts. Calcification of the cyst wall, as occurred in our first case, has been rare, and aside from increasing the difficulties of the removal of the cyst, or making it impossible to completely extirpate the cyst (one of Tuffier's cases), would not seem to be a serious matter either from the standpoint of the approach or from that of post-operative complications. *Hæmorrhage* from the cyst occurred in one of our cases (Case IV) and has been noted repeatedly in the literature on dermoid cysts. It may be slight and oft repeated, may be moderately severe and produce a serious anæmia, or may be massive and even fatal. At least five cases in the literature died from a massive hæmorrhage from the cyst. Thus far hæmorrhage has not altered surgical procedure except to delay operation until it has been recovered from either naturally or through heliotherapy or by blood transfusion. The massive hæmorrhages which have resulted fatally in a number of cases have as yet presented no surgical aspects. They have been sudden, unexpected and rapidly fatal. Did they happen under favorable conditions surgery might find means of dealing with them.

*Infections*, then, constitute the important complications which may influence the surgical treatment of dermoid cysts and teratomas. They may involve the cyst alone or they may extend so as to involve the mediastinal structures, the pleura, the tissues of the neck, and the bony thoracic wall. The origin of these infections is not always clear. They have followed respiratory infections, as in one of our cases, and a number in the literature; they have occurred subsequent to the rupture of a cyst into the bronchus, and they have followed incision into or tapping of the cysts. In some of the reported cases it is not apparent how the infection supervened. The results of infections have been intracystic or intrateratoid abscesses, empyemata, abscesses presenting in the neck or chest wall and adhesions to the pleura, to the pericardium and great vessels, and to the tissues of the neck. In the

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literature some of these infections or abscesses have extended or perforated into the pericardium, pleura, bronchus, lung or great vessel. Our Case II is a typical, although exaggerated, example of such infections with multiple abscesses within the teratoma, an abscess of the neck and a chronic empyema. In the literature at least ten cases presented a swelling in the neck which was incised by the physician or surgeon; more than twenty cases perforated into a bronchus with a resulting secondary infection in the cyst, some five or six had empyema and an occasional case some other infection, as pericarditis.

In the presence of such infections how shall we proceed, granting we have in mind the attempt to remove the tumor? Shall we proceed at once, as has often been done in the literature, to the removal of the lesion, regardless of the complications which may result; or, shall we first attempt to control the infection before attempting the removal of the lesion? A review of the literature shows that post-operative infectious complications, in part at least due to the existence of pre-operative infections, have altered considerably the immediate results, the convalescence and the eventual physical results. They have been the cause of a number of deaths (about 20 per cent.) and they have often resulted in the infection of a large cavity, which in some cases has necessitated multiple thoracoplastic operations over a period of years to finally cure. The result has been a prolonged convalescence with pulmonary impairment and an unsightly deformity. It would appear better, in view of our experiences with Case II, to first attempt to cure the infectious complications such as an abscess of the neck and empyema and to prevent subsequent infectious complications by isolating through adhesions the infected dermoid or teratoma from surrounding structures before attempting the removal of the tumor. To accomplish this may mean, as in our case, a preliminary operation and several months of effort. But the result in Case II would seem to justify the time and effort, for aside from a localized chondritis no post-operative infectious complication occurred, the empyema did not recur and the patient recovered with a lung completely expanded.

With regard to the proper approach to the mediastinal dermoids I have stated that in uncomplicated dermoids the long intercostal incision or one combined with the resection of a single rib is, in our opinion, desirable. When, however, we come to speak of complicated dermoids, meaning by that term dermoids complicated by infection, the method of approach will depend upon the nature and extent of the infection. Two matters come up for consideration; whether the approach will, in the presence of the infection and its accompanying adhesions, permit the exposure and removal of the tumor, and whether it will be likely to result in the spread of the infection, with the possible development of serious post-operative complications. Consider, for example, our Case II, an infected teratoma associated with a chronic empyema. The approach to this lesion through a long intercostal incision (which I have considered ideal for uncomplicated dermoids), either before or after the cure of the chronic empyema, would have meant the wide separation of dense adhesions between lung and parietal pleura and tumor,

which had it been possible, would again have exposed a wide field to infection. It would seem far more desirable to first cure the infection through a preliminary operation and at the same time isolate the tumor from surrounding structures, so as to prevent further infection at its subsequent removal; and having accomplished this to approach the lesion by the local resection of ribs directly over it and remove it through the defect in the thoracic wall thus produced. The failure so to guard against infection has, as I have indicated, often led to death. For dermoids complicated by infection, we would, therefore, suggest as a proper approach the local resection of ribs over the tumor; having first cleared up the surrounding infections and isolated the tumor from the surrounding structures.

While complete extirpation of dermoids is the treatment of choice we



FIG. 13.—X-ray of the thorax in Case III; the arrow points to the lesion.

should recognize that it is not always feasible, or at least not always desirable. Tuffier has called attention to this point in reporting a case in which extensive calcification of the cyst made complete removal impossible; and it is particularly in the infected dermoids that it applies. Dermoids may be intimately adherent to the pericardium and to the great vessels in the mediastinum; and in the presence of infection a cleavage plane between them may not be found. It is

quite possible to enter the pericardium, or to tear into a great vessel, with a resulting fatal pericarditis or an alarming or fatal hæmorrhage. In one of the cases of total extirpation in the literature in which the pericardium was opened a brilliant operation was promptly followed by a fatal pericarditis; and other catastrophies have followed the too zealous effort to completely remove the lesion. Both the literature and our own experience with two cases show that with proper handling, and by that I mean careful control of infection and a proper approach, incomplete extirpation may yield very satisfactory results.

CASE III.—A white woman, thirty-three years of age, entered the Cincinnati General Hospital January 26, 1928, complaining of shortness of breath and choking sensations. For eleven years she has had shortness of breath on exertion and choking or smothering spells. There was no etiological factor so far as could be determined. More recently, and especially in the past two months, the symptoms have increased in severity so that



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she has become very dyspnoeic. In addition there have been pains through the chest, tenderness on pressure over the sternum, and a dry, hacking, unproductive cough. There has never been any hemoptysis, fever, or loss in weight. Her history otherwise is unimportant.

*Physical Examination.*—A fairly slender, though well-developed white woman, without obvious discomfort. No cyanosis; no enlargement of the superficial vessels about the neck or upper thorax. Examination of the eyes show on the right a typical Horner's syndrome, with ptosis, enophthalmos and contracted pupil. The physical examination otherwise is quite negative. The chest is symmetrical and the respiratory movements equal on the two sides. The examination of the heart and lungs fails to show any abnormalities. Subsequent examinations showed an occasional prolongation of expiration at the right apex and on one examination a friction rub was heard in the region of the fourth rib. The red blood cells were 4,800,000; hæmoglobin 100 per cent.; differential count failed to show any gross abnormality; urine negative; Wassermann test negative. The X-ray of the chest showed a tumor mass about the size of an egg lying in the

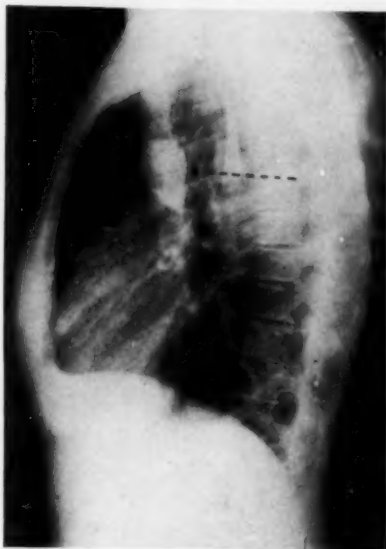


FIG. 14.—X-ray of the thorax in Case III. Lateral view.

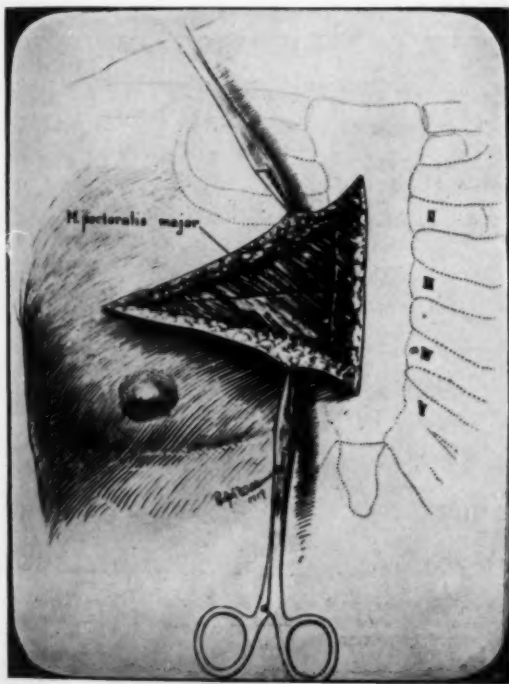


FIG. 15.—Mediastinal approach to the lesion in Case III. (Tuffier-LeFort.) From Keen's "Surgery," vol. viii.

the third and fifth ribs exposed at their junction with the sternum. (Tuffier-LeFort

mediastinum to the right of the mid-line about opposite to the seventh dorsal vertebra. This mas was very closely outlined as seen in Figs. 13 and 14. It was the opinion of the röntgenologist that this was a dermoid cyst.

The diagnosis of mediastinal tumor was made entirely on the X-ray findings, for there were not sufficient physical signs to suggest such a diagnosis. In the absence of any positive findings such as the expectoration of hair, etc., a positive diagnosis of the lesion could not be made. The pre-operative diagnosis was a probable dermoid cyst of the mediastinum.

The operation was performed February 23, 1928, under intratracheal ether anaesthesia. The approach to the lesion was through an incision along the fourth rib on the right side, with the resection of the fourth rib from the sternal margin to the anterior axillary line. A vertical incision was made at right angles to this along the right border of the sternum, and the costal cartilages of



approach, Fig. 15.) These cartilages were divided, but before this was done the parietal pleura was mobilized by stripping it away from the anterior thoracic wall.

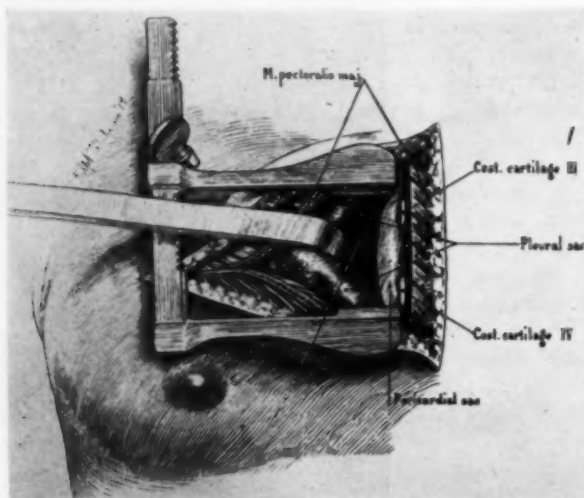


FIG. 16.—Mediastinal approach to the lesion in Case III. The mediastinal pleura has been mobilized and retracted laterally. From Keen's "Surgery," vol. viii.

In attempting to completely surround the tumor it was ruptured at one point and a mass of white, cheesy material escaped. No hairs were found in this material on hasty examination. Having ruptured the capsule of the mass, its entire contents were removed with a large gall-bladder scoop. The capsule collapsed following the removal of its contents and was only partially removed. A piece of rubber tubing was placed in the cavity and a couple of cigarette drains placed around the tube. The wound was closed tightly excepting at the point of emergence of the tube and drains.

A microscopic examination of the cheesy material showed it to be made up of detritus, cholesterin crystals and degenerating epithelial cells. No hairs were found.

#### *Post-operative Course.*

Following operation there developed a mediastinal infection and then a right empyema. The operative wound partially broke down and had to be more widely opened to secure better drainage of the mediastinum. The empyema was treated by aspiration drainage. The convalescence of the patient was, therefore, much prolonged. The mediastinal and pleural infections,

A rib spreader was placed in the wound and opened widely so as to give an adequate exposure of the field. The parietal pleura was mobilized further mesially until the mediastinal pleura could be retracted laterally. A fairly satisfactory exposure of the mediastinum could thus be obtained without opening the pleural cavity. (Fig. 16.) The tumor proved to occupy a deeper position than was anticipated. When exposed it was found to lie posterior to the pulmonary vessels and to be crossed by the azygos vein. It was necessary to doubly ligate and divide the azygos vein before the tumor could be satisfactorily freed.

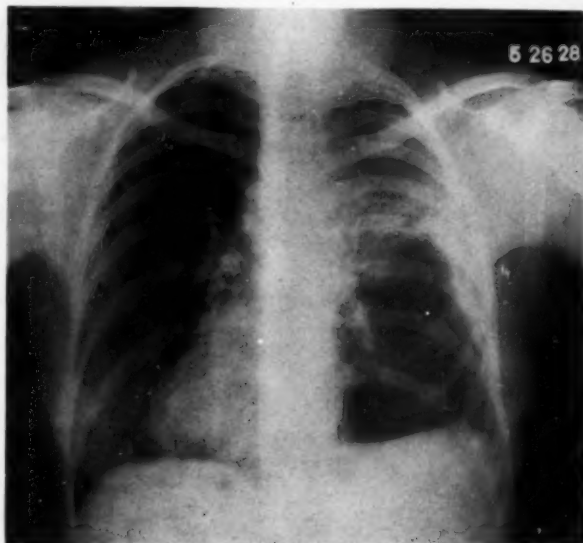


FIG. 17.—Post-operative X-ray of the thorax in Case III. The slight cloudiness of the right thorax is presumably the result of the post-operative empyema.

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however, eventually cleared up and the wound completely healed. The patient at the present time, May 1, 1929, is well and free from the subjective symptoms complained of before operation. Post-operative X-rays (Figs. 17 and 18) showed the disappearance of the mass.

*Discussion.*—Although the end result in this case was quite satisfactory it seems to confirm some of the statements I have already made. The approach to the lesion was unsatisfactory and the exposure, because of the depth of the wound, inadequate. A transpleural approach through a long incision with the resection of a single rib would have been better. As has been stated in preceding pages infection has not uncommonly followed the removal of uncomplicated as well as complicated dermoids. Whether the infection in the above case was introduced from without or came from the dermoid it is impossible to say; but a perusal of case reports in the literature, and our experience with Case II, shows that a dermoid or teratoma wholly unconnected with a bronchus, the lung or other structure may become infected, following acute infections and especially acute respiratory infections. Indeed a dermoid, quiescent and symptomless for years, may become active and provoke symptoms following such infectious conditions; or exacerbations in symptoms already present may follow them. It would appear that latent infections exist in apparently uncomplicated dermoids; and if this is true an approach should be selected with the possibility of post-operative infection in mind. The approach we used was unsatisfactory

from this point of view; for in the presence of infection the wound broke down principally because of the separation of the divided costal cartilages. The result was a wide open wound, which, had we not been fortunate in not opening the pleura during operation, would have resulted in a large open sucking wound with a pyopneumothorax—a most fatal complication. Even though we escaped this complication we had two distinct conditions to deal with—a suppurative mediastinitis and an empyema, the former of which gave us by far the greater concern. The question arises whether with a transpleural approach an infection originating within the dermoid or during operation would not drain directly into the pleural cavity and give rise to an empyema rather than a spreading mediastinitis. If so, and we favor this idea, the problem of infection becomes simpler for not only is the mortality



FIG. 18.—Post-operative X-ray of the thorax in Case III. Lateral view. Compare with Fig. 14.

less but the possibility of dealing with the empyema without the breaking down of the operative wound is greater.

The case also supports the statement made in previous pages that incomplete removal of a dermoid may give very satisfactory results.

CASE IV.—M. S., a white woman, twenty-three years of age, was admitted to the Cincinnati General Hospital April 24, 1928, complaining of cough, precordial pain and hemoptysis. The onset of her illness began four years before admission, when, without

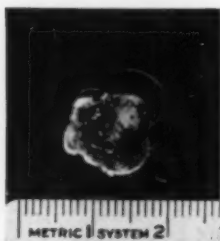


FIG. 19.—Photograph of a fragment of material expectorated by Case IV, showing hairs attached.

previous cough, expectoration, or other symptoms, she suddenly expectorated about a teaspoonful of bright red blood. She consulted a physician who made a diagnosis of pulmonary tuberculosis. An X-ray of the chest at the time showed a mass which had remained unchanged in all subsequent examinations. About a year after the onset of her illness she coughed up some "yellow clay-like particles which had short yellow hairs attached to them"; and since that time she has coughed up similar material three or four times, once in association with a severe hæmorrhage.

(Fig. 19.) There had developed a slight, hacking cough with a small amount of mucopurulent sputum which occasionally was blood tinged. For two years she had been unable to breathe comfortably while lying on her back; and for a week before admission she had been markedly short of breath with "smothering spells." There had been no pain in the chest excepting for a short period of a year before admission, at which time she had sharp, precordial pain accentuated by breathing. There had never been any cyanosis. Palpitation of the heart had been present for the two years previous to admission, but recently had been less marked. There had not been any loss of weight.

*Physical examination* showed a well-developed and well-nourished white girl, apparently not acutely ill and without any marked discomfort. She was somewhat pale but without cyanosis; pulse, 82; temperature, normal; and respirations, 18 per minute. The thorax was well formed. The left upper thorax appeared slightly fuller than the right and there was definite limitation of motion in this region as compared with the right. Percussion elicited an area of dullness over the left upper thorax in front, but not behind. On auscultation over the left apical region and extending down to the third I. S. in front, the breath sounds were intensified and roughened and accompanied by many medium, coarse râles. Pressure upon the front of the left chest over the second rib, and extending downward three inches, gave rise to pain and discomfort which was very definite, and quite localized. The examination of the chest otherwise was quite negative. The blood pressure was 110/60. The red cell count

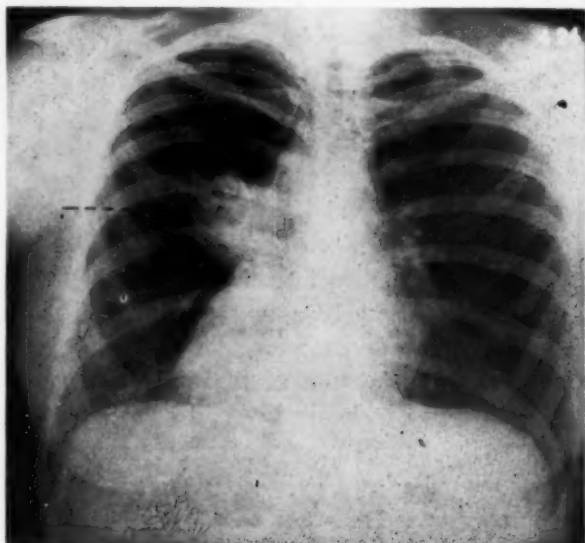


FIG. 20.—X-ray of the thorax in Case IV, showing the dermoid cyst projecting into the left thoracic cavity.

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was 4,300,000; the hæmoglobin 80 per cent. The white cell count was 9200. The urine was negative. The X-rays of the thorax (Figs. 20 and 21) showed a shadow in the left anterior mediastinum about five centimetres in diameter; its mesial border continuous with the mediastinal shadow, its lateral border irregular in outline. The diagnosis of dermoid cyst was made upon the definite finding of hairs and cheesy material in the sputum.

*Operation.\**—April 28, 1928. Under intratracheal anaesthesia an incision was made over the third left rib in front and the rib resected from the lateral border of the sternum to the anterior axillary line. With the finger the underlying pleura was stripped from the chest wall as widely as possible. A short skin incision was then made along the left border of the sternum and at right angles to the first incision and the cartilages of the second and fourth ribs exposed. These were divided transversely where they joined the sternum. A rib spreader was then placed and opened giving a wide triangular field, the base of which was at the sternal border; the apex, in the axilla. (Fig. 16.) The mobilization of the pleura which had not yet been opened was continued mesially so that eventually the mediastinal pleura could be reflected laterally, thereby exposing the left border of pericardium, the great vessels of the mediastinum and the dermoid cyst. The cyst lay as the X-ray showed in the angle formed by the base and the left border of the heart. The freeing of the cyst from the pericardium and great vessels offered no great difficulties and, indeed, the cyst was far less adherent than in any of the previous cases. After it had been accomplished this portion of the cyst was grasped and lifted upward and the lateral borders of the cyst surrounded. It became evident that the communication between the cyst and the bronchus was at the lower lateral pole of the cyst for here the cyst was densely adherent to the lung; and here during our manipulations the pleura was for the first time opened. The opening was temporarily occluded with gauze while the operator cut across the connection between the cyst and lung. On the removal of the cyst the communication between it and the bronchus was found to be large, easily admitting the little finger of the operator. A considerable quantity of heavy, cheesy material was found in the bronchus, having perhaps been squeezed into it during the removal of the cyst. As much of this material as possible was removed. An attempt was made to close the bronchus by an encircling ligature of catgut supplemented by a series of sutures which brought the lung together over it. The rent in the pleura was closed. The wound was closed in layers. The divided costal cartilages were reunited with chromic catgut. Two small cigarette drains were placed extrapleurally down to the neighborhood of the closed bronchus. The skin was closed air-tightly about the drains with silk.

*Post-operative.*—The patient left the operating table in good condition. Three hours after operation she was restless and had severe paroxysms of coughing. Her pulse rose to 130, but was regular, and of good quality. Respirations were regular and normal. Eight hours after operation breathing became shallow and cyanosis appeared. Examination of the wound showed some crepitus in the tissue about it, but no fullness at the root



FIG. 21.—X-ray of the thorax in Case IV. Lateral view.

\* This case was operated upon before the Society of Clinical Surgery.



of the neck to suggest a mediastinal emphysema. The chest was bandaged tightly, oxygen given with a cone, and 750 cubic centimetres of glucose administered intravenously. There was much mucus in the throat which could not be altogether successfully removed. The dyspnoea increasing, a trocar was introduced into the left pleura on the supposition that she had a tension pneumothorax, and connected with a rubber tube, the distal end of which was under water. This failed to relieve the dyspnoea and cyanosis, but some hours later her respirations improved and her cyanosis became less marked. About 4 o'clock the following morning after being apparently greatly improved, she suddenly became cyanotic and her respiration stopped. Efforts at resuscitation were unavailing. An autopsy was not obtained.

*Pathology.*—The specimen consists of a thick walled cyst about 5 centimetres in diameter, partly filled with thick, white cheesy material and abundant blond hairs. The lining of the cyst looks like skin which is thrown into large irregular folds and provided with hair. Microscopic sections show the lining to be made up of typical skin containing hair follicles, sebaceous glands and a few sweat glands. In the loose, areolar tissue beneath the skin are many small lymphocytes and a few polymorphonuclear cells.

*Discussion.*—While the exposure was perfectly satisfactory the attempted extrapleural mediastinal approach proved in the end to have no particular advantage over a transpleural approach; for the pleura was unavoidably opened at the moment that the dermoid was separated from the lung. It is to be noted, however, that the opening of the pleura could have been avoided had we been satisfied to do the operation in two stages; for the dermoid could have been delivered through the thoracic wall and removed at a second sitting. In retrospect our fault probably lay with the treatment of the lesion. Not until after I had removed the cyst did I realize how large was the bronchus with which it communicated. Although it is speculation I think that one or both of two things happened; either the closure of the bronchus was insecure and gave rise to a pneumothorax which was not recognized; or that during the manipulation of the cyst a quantity of the cheesy material within it was squeezed into the bronchus which because of the operation could not be expelled and which occluded the major bronchi. In any event would it not have been wiser, in view of the known communication with a bronchus, to have brought the cyst out through the thoracic wall and removed it at a second sitting?

#### CONCLUSIONS

From an experience with these four cases of mediastinal dermoid and a survey of the literature, I would suggest: (1) That in uninfected dermoids the approach be by a long, intercostal incision or one combined with the resection of a single rib. (2) That in infected dermoids or teratomas the approach be such that the infected lesion may be isolated from surrounding structures. The approach by multiple rib resections perhaps best meets this requirement. (3) That in complicated infected dermoids and teratomas it is wiser to attempt to clear up the infection before the removal of the lesion than to chance coping with the infections which may follow the immediate removal of the lesion. (4) That total removal of mediastinal dermoids is undoubtedly the treatment of choice. From the literature it has been fol-



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lowed by the highest percentage of cures with the lowest mortality. These results are, of course, in large part due to the fact that the cases in which this procedure was possible were in greater proportion simple, uninfected or otherwise uncomplicated dermoids. But I wish to point out that complete removal, either because of extensive calcification, infection, or adhesions is not always possible, or if possible, is not always desirable because of the danger of post-operative complications; and that it is better to be content, in certain cases, with less than a complete extirpation, especially since good results may be obtained in this way. The literature contains examples of poor judgment in this respect. (5) That the communication of a dermoid with a large bronchus introduces a factor, which, I think, was responsible for the death of one of my cases. How to deal successfully with the situation I have not yet discovered either from my own experience or from the literature. Should I meet again with it I shall be tempted to deliver the dermoid through the thoracic wall, if that is possible, and remove it after the lung has become adherent to the parietal pleura around the point of communication. (6) That in uninfected dermoids closure of the thoracic wound should be complete and air-tight. In the literature there are many examples of drainage or tamponade of the large cavities left after the removal of the lesions. The results have been unsatisfactory. The cavity has become infected, and, if the patient has survived, multiple thoracoplastic operations have been necessary to obliterate it, the convalescence has been greatly prolonged and an unsightly deformity has resulted. It has been the experience of most observers that a post-operative pleural effusion is a common sequel of tumor removals. This may be treated by aspiration; or, if infected, by continuous air-tight suction drainage. This drainage should be instituted, not through, but far away from the closed thoracic wound, under which circumstances the result may be as satisfactory as in simple empyema.

## CONGENITAL MEDIASTINAL CYSTS OF GASTROGENIC AND BRONCHOGENIC ORIGIN

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MEDIASTINAL tumors are rarely encountered in childhood. In 1924 Smith and Stone<sup>1</sup> reported two cases from the Children's Hospital of Boston, one of which was a teratoma. They collected from the literature and summarized eight similar cases occurring in children under twelve years of age. Of one

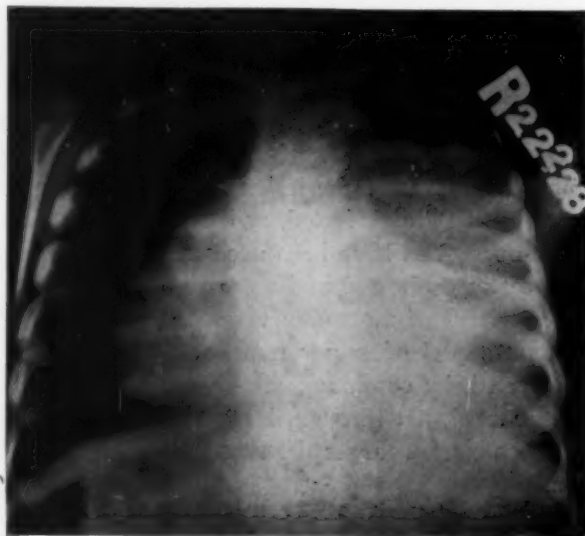


FIG. 1.—Case I. On admission. Diffuse clouding of right side of thorax suggesting pleural effusion.

hundred and thirty-nine thoracic dermoids and teratomata collected by Kerr<sup>2</sup> in 1928, and including his personal case, only eleven occurred in the first decade of life. Recently, three cystic mediastinal tumors have come under our observation that are in a measure comparable to the dermoids, but differ from them histologically. The teratoma is an extremely complex tumor and is composed of tissues derived from all three germinal layers. The der-

moid is of simpler structure arising from but two of the three primary embryonal layers. Whereas the dermoid is of ectodermal and mesodermal origin, the tumors we are describing are composed of endothelial and mesothelial derivatives. Two of these cysts are apparently of gastrogenic origin; the third is of bronchogenic derivation. Although the highly differentiated teratomata have been found to contain gastro-intestinal derivatives among other complex structures, we have failed to find mention, in the literature, of the occurrence of the gastrogenic type of cyst of the mediastinum.

CASE I.—A white boy, twenty-two months of age, one of six children, was admitted to the Children's Hospital February 20, 1928. The family and past histories were without bearing on the present illness. He had always been well until two months before entry at which time he was supposed to have had a right-sided pneumonia with a high fever for four days. The temperature then returned to normal and after two weeks in bed the patient was allowed up. During his illness he lost considerable weight.

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FIG. 2.—Case I. After aspiration. Shadow running obliquely from hilus to diaphragm on right.

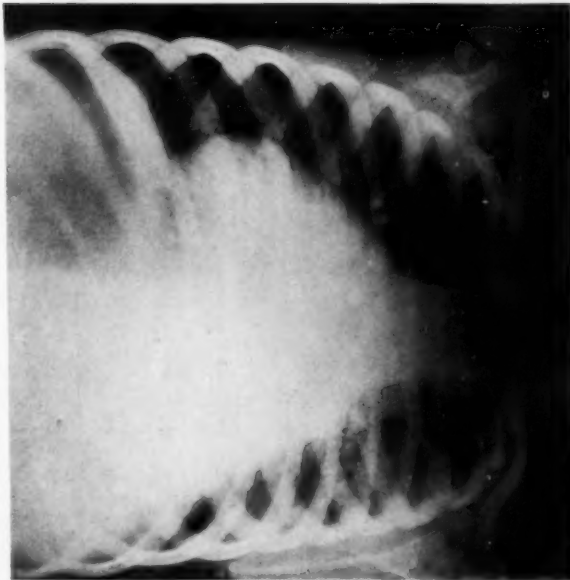


FIG. 3.—Case I. Cyst injected after external drainage. Shrinkage of the cyst has begun.



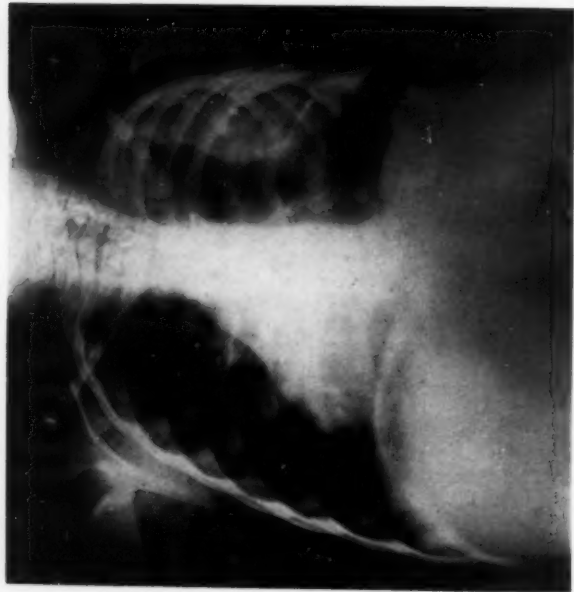


FIG. 4.—Case I. Two months after excision of cyst. Lung shows considerable expansion.

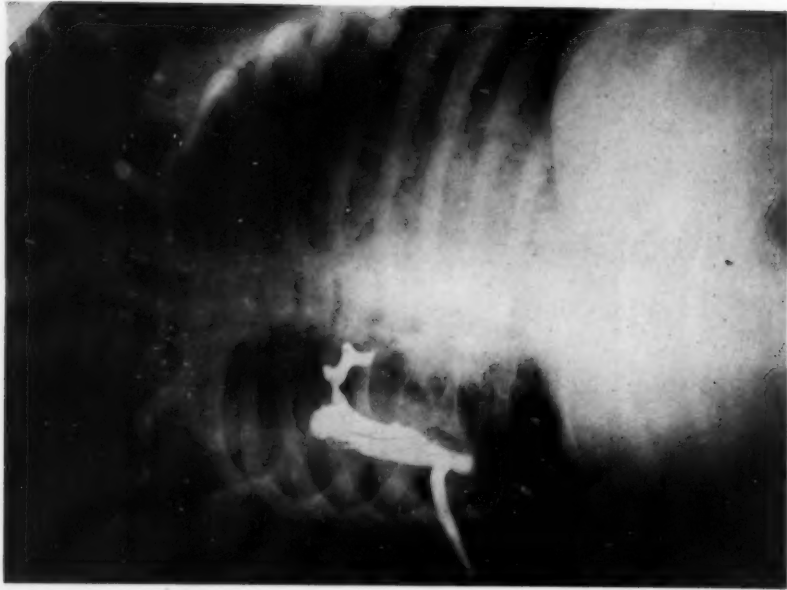


FIG. 5.—Case I. Four months after excision. Sinus injected. Iodide has flowed back onto chest wall, obscuring superficial portion of sinus.

## CONGENITAL MEDIASTINAL CYSTS

*Present Illness.*—Four days before entry the patient became ill with fever, dyspnoea and vomiting. After the first day the fever subsided but the vomiting continued. The morning of entry the right ear began to discharge purulent material.

*Physical Examination.*—Temperature  $101^{\circ}$ , pulse 130, respirations 40-50, weight twenty-one pounds. The child was pale, undeveloped and malnourished, sick and irritable, and could lie only on his right side. He was dyspnoeic with the *alae nasi* dilating and breathed with an expiratory grunt. There was a frequent harsh, brassy cough. A purulent otitis media was present on the right side. The chest was barrel-shaped with marked costal retraction and with diminished expansion on the right. The right lung was flat, breath sounds were diminished over the greater part, and absent below the angle of the scapula. A few moist râles were present. Tactile fremitus was absent over the right lower back. Bronchial breathing was heard over the right upper chest anteriorly. The heart was displaced two and one-half centimetres outside the left nipple line. The abdomen was protuberant and both spleen and liver were palpable five centimetres below the costal margin. The fingers showed suggestive clubbing.

The X-ray examination suggested fluid, and a tentative diagnosis of empyema was made. Thoracentesis yielded 360 cubic centimetres of a milky, viscid opalescent fluid. The fluid was acid in reaction; its specific gravity 1.010; chloride 114 cubic centimetres neutralized 100 cubic centimetres N/10 NaOH; bicarbonate 34 vol. per cent.; 560 cells, 80 per cent. polymorphonuclears. The withdrawal of the fluid afforded temporary relief of the symptoms. The diffuse clouding of the right chest by X-ray was replaced by a clear lateral lung field and a large, dense shadow running obliquely downward and outward from the hilus. Intratracheal injection of lipiodol through the crico-thyroid membrane gave no diagnostic assistance, though the right upper bronchus failed to fill. The fluid rapidly reaccumulated and repeated tapings were necessary. The child continued to run a low-grade temperature. In view of the character of the fluid and the röntgenological findings, diagnosis of intra-thoracic cyst was made.

*Operation.*—March 14. Gas-oxygen anaesthesia. Exploratory thoracotomy. The right upper lobe was atelectatic, rubbery and yellowish-red in color. The two lower lobes were only partially expanded and displaced forward by a large, tense, smooth-walled cyst extending from the diaphragm to the apex of the thorax and filling the spinal gutter. There were no adhesions within the pleural cavity. The cyst was estimated to fill two-thirds of the right thoracic cage. In front it was covered by the visceral pleura which was reflected laterally onto the thoracic wall and mesially along the mediastinum, posterior to the root of the lung. In diameter it appeared to be about two and three-quarter inches at its diaphragmatic attachment, which was retropleural. It was slightly smaller at the apical limit of the tumor which was covered by pleura. The condition of the child did not warrant enucleation at this time. The cyst was sutured to the chest wall and opened six days later and drained by catheter.

The latter procedure was followed by a very severe reaction with a high fever.

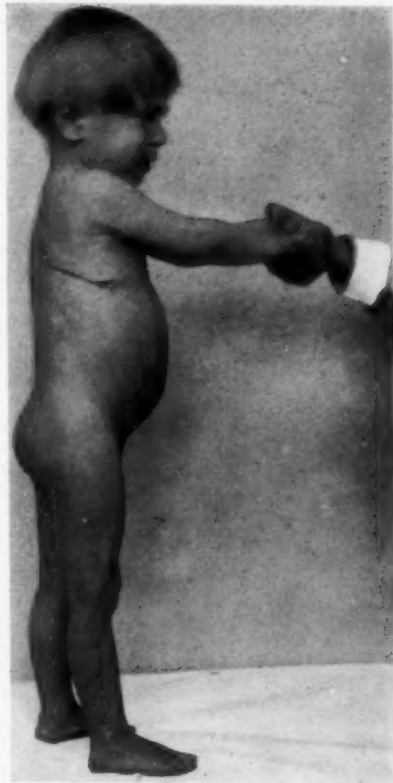


FIG. 6.—Case I. General condition six months after excision of cyst.



Four transfusions were given at intervals and there was gradual improvement. There were recurrent infections of the cyst cavity, however, with elevation of temperature. There was no gain in weight, but the brassy cough ceased. Repeated X-rays with lipiodol injection demonstrated considerable contraction of the cyst. There was a copious amount of clear white mucoid drainage.

*Second Operation.*—July 23. Gas-oxygen anaesthesia. The old incision was reopened. The seventh rib was excised. The cyst was found to be approximately one-half its

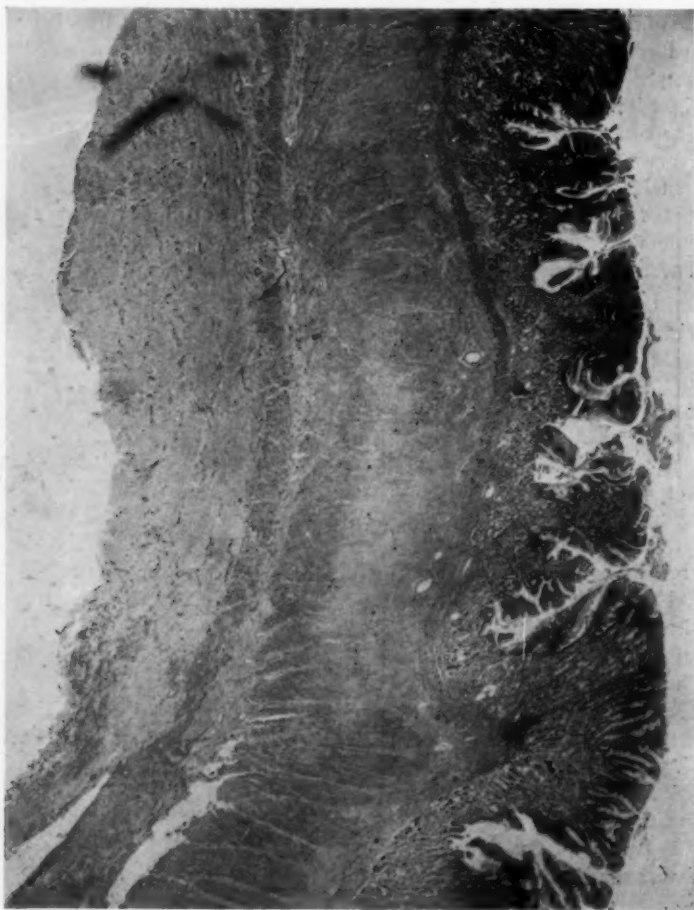


FIG. 7.—Case I. Low power. Mucous membrane, submucosa and two layers of smooth muscle fibres are present.

former size. The wall was greatly thickened and fibrous. The condition of the three lobes of the lung remained the same as at the previous operation. The pleura was incised vertically over the surface of the cyst. No cleavage plane could be found and the cyst was freely opened and with a finger introduced into the cavity the cyst was excised by sharp dissection, including the overlying pleura that could not be detached. The greatest difficulty was encountered in excising the lower end of the tumor where a prolongation appeared to dip down into or through the diaphragm. This prolongation appeared to be about three-eighths inch in

depth and three-fourths inch in diameter. There was relatively little haemorrhage. A gauze drain was left at either end of the incision to control oozing and the wound was approximated closely about them.

The child's condition was precarious at the end of operation. An intravenous injection of glucose was given, followed some hours later by the transfusion of 300 cubic centimetres of blood, following which the child picked up well and made a satisfactory convalescence.

He has been followed for eight months. The wound is now closed except for two small sinuses that discharge the original fluid, presumably from a portion of the cyst remaining. The general condition has shown remarkable improvement, the weight now being twenty-six and one-half pounds.

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*Pathological Report.*—Cyst of mediastinum. Specimen consists of three large fragments of tissue and a number of small ones. The largest of these are 6 x 3 x 1 cm., 4 x 2 x 1 cm., and 2 x 1 x 1 cm. These are composed of very firm grayish-white tissue, with occasional areas which are somewhat nodular on palpation. The inner surface is partly covered by blood clot and grayish tissue which has some purulent material over some of the areas. In the largest fragment there is noted on the inner surface an elevated area which is a pinkish-gray color and is somewhat soft. This area is more or less circumscribed and has a definite margin. The appearance of this tissue is that of granulation tissue. In none of the fragments was one able to find gross evidence of hair.

*Microscopic.*—Six sections, two of which show what is histologically apparently stomach wall. They are lined on one side by gastric mucosa, with submucosa, muscularis, mucosa and muscular layers underlying. There are numerous Paneth's cells in the mucosa. The rugae are present in some areas with strands of smooth muscle as seen in the normal stomach wall. The mucosa is destroyed in places by fibrous tissue, and scattered throughout there are areas of hemorrhage and cellular infiltration, chiefly polymorphonuclears and plasma cells with many lymphocytes.

One section is through a very active lymph gland, showing many hyperplastic follicles and scattered areas of necrosis and perivascular infiltration. The remaining three sections show chiefly fibrous tissue with some smooth muscle and fat. There is one small area of striated muscle. There are scattered areas of necrosis and cellular infiltration and marked perivascular infiltration. There are nerve trunks of various sizes in all sections and a portion of a ganglion in one. *Diagnosis.*—Chronic inflammatory tissue. Smooth muscle and hyperplastic mucosa, histologically of stomach wall.

**CASE II.**—A white, male infant was admitted to the hospital September 14, 1927, at the age of seven weeks, because of distress, especially after nursing.

The family history was negative. The birth weight was nine and three-quarter pounds. From birth he cried a great deal. He was unable to nurse longer than five minutes when he would suddenly stop, double up the legs, throw back the head and cry as though in pain. The acute distress would continue for about a half hour and prevented the infant from obtaining an adequate amount of sleep. On physical examination he was found uncomfortable with paroxysms of crying as though in pain. The weight was six ounces more than at birth. There was no respiratory distress and the routine physical examination was negative. With the exception of a white blood count of 37,000, the laboratory studies were also negative. He was in the hospital two weeks and became much more comfortable, gained three ounces, and being breast fed was sent home.

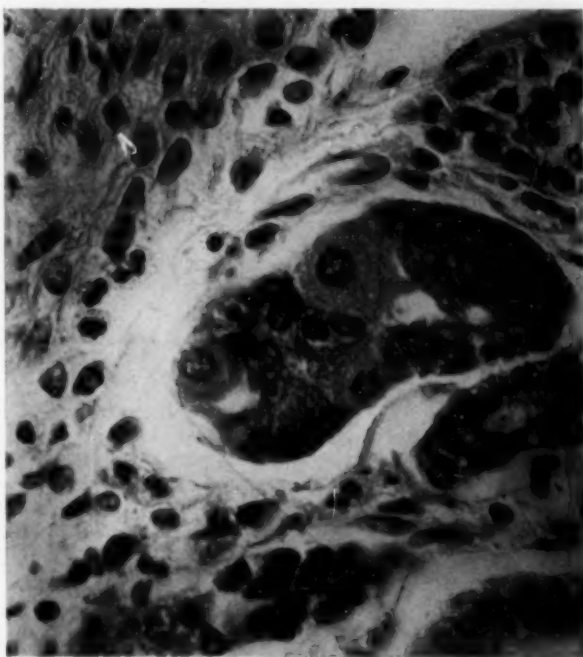


FIG. 8.—Case I. High power. Typical gastric glands, such as are seen in the fundus of the stomach, with chief and parietal cells present.



FIG. 9.—Case II. Before aspiration. Diffuse clouding right upper chest extending across to left of median line.



FIG. 10.—Case II. After aspiration. Arrow points to erosion of rib from pressure of cyst.

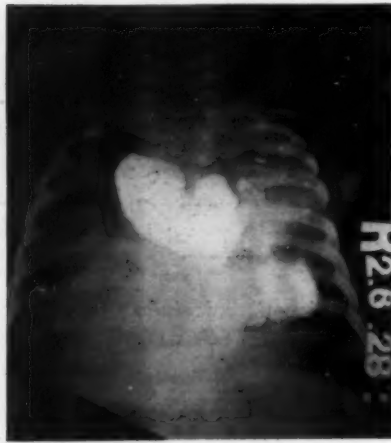


FIG. 11.—Case II. Cyst injected following aspiration. Anteroposterior view.



FIG. 12.—Case II. Cyst injected following aspiration. Lateral view.

## CONGENITAL MEDIASTINAL CYSTS



FIG. 13.—Case II. Gross specimen obtained at autopsy. Cyst opened, showing mucosa thrown into folds.

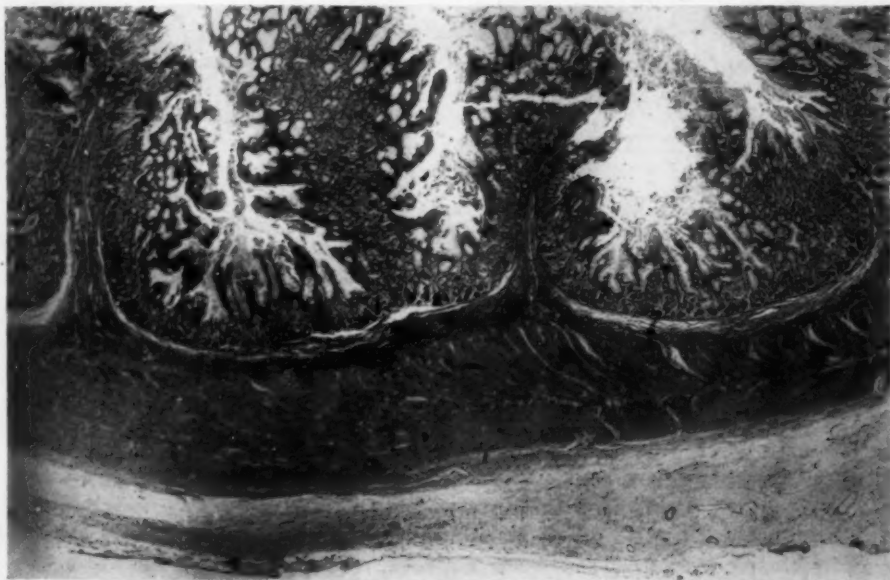


FIG. 14.—Case II. Low power. Mucosa, submucosa, two layers of smooth muscle and serosa are present.

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One week later he was readmitted with persistence of the original symptoms. The weight was now eleven pounds. Temperature 100.6°, red blood count 3,600,000, haemoglobin 60 per cent., white blood count 21,500, 74 per cent. polymorphonuclears. The spinal fluid Wassermann reaction was negative. There was a palpable spleen. Pathology was suspected in the chest and an X-ray showed a "pneumonia of unusual distribution—tuberculosis to be considered." Tuberculin 1-25 was negative. The respirations became more difficult, and the patient began to hold the head retracted. Dulness and bronchial breathing appeared over the right upper chest and X-ray showed an extension of the process and malignant disease was suggested. A barium meal showed that there was no oesophageal obstruction. An area of pressure erosion was found in the region of the angle of the fourth and fifth ribs posteriorly, and thoracentesis was attempted in this area. After penetrating about an inch, a cyst was punctured and fluid under pressure

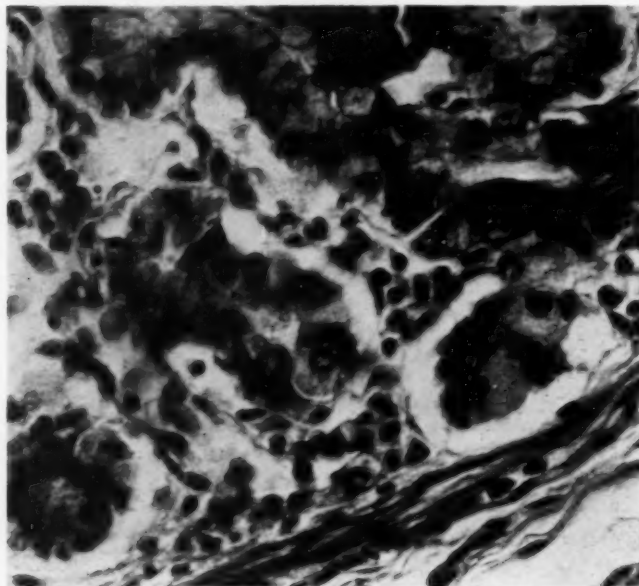


FIG. 15.—Case II. High power. Typical gastric gland structure present with chief and parietal cells.

nearly shot the plunger out of the syringe. The fluid was thick, viscid, mucoid, and contained 700 cells, mostly red blood cells, with a moderate number of lymphocytes. No organisms, hairs or epithelial cells were seen. Having demonstrated a cystic cavity, a second tap was attempted and thirty-five cubic centimetres of similar fluid under pressure was removed, the last five cubic centimetres of which was mixed with old blood, and eight cubic centimetres of lipiodol was injected. The X-ray showed a large multilocular cystic cavity posterior to the trachea and

oesophagus, and displacing them forward and extending laterally behind the lung toward both apices.

At seven months his weight was the same as at birth. He had developed a very loose, brassy cough and on several occasions coughed up considerable amounts of blood. A month later an unsuccessful attempt to find the cyst surgically was made, and two weeks later a second attempt to approach the cyst surgically failed. The patient's general condition seemed stationary and he was sent home June 4, 1928, at the age of ten months, weighing ten and one-half pounds.

Three months later he was readmitted for the third time, in the hope that the cyst had filled up to the point where it could be enucleated surgically. His weight was now eleven pounds and the general symptoms were the same as before. The head was held in marked retraction; the fingers now were definitely clubbed. A thoracentesis failed to enter the cyst and so no further surgical exploration was attempted.

The patient was in the hospital four months, failed to gain, had several exacerbations of a chronic pneumonia and finally died of bronchopneumonia at the age of sixteen months, weighing ten and one-quarter pounds.

The findings at post-mortem were as follows:



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The tumor mass was found attached in part to the apex of the right lung by fibrous tissue, while the remaining tumor mass was separated from the lung by a serous membrane which covers part of the lung and wall of the cyst, forming a definite serous cavity. The entire tumor mass was found to be five centimetres in diameter and was composed of two portions, one of which at this time was a thin, fibrous, cystic mass which extended into a cavity which had been formed by the erosion of the bodies of the vertebrae and in part involved a portion of the adjacent ribs. The second portion of this cavity communicated with the previously-mentioned portion of the cyst by two small openings. The second portion of the cyst was composed of what in the gross appears to be a portion of gastro-intestinal tract, the mucosa of which has numerous folds, a definite submucosa, several layers of smooth muscle and a serosa, the latter covering a portion of the second lobule of the cystic mass. These cystic structures do not appear to be associated or directly connected with the trachea, oesophagus or bronchi, it appearing as an isolated structure, partially attached to the apex of the lung.

*Microscopically.* — The mucosa lining the second portion of the cyst is composed of deep branching glands, the cells of which are of a mixed type, being composed of parietal and chief cells. The smooth muscle assumes an orderly arrangement and there is present a serosa such as one finds in a normal gastro-intestinal tract.

CASE III.—A white female, three months of age, was admitted May 27, 1927, with the history of cyanotic attacks for two months.

The family history was negative. The birth weight was eight pounds. There was no convulsion or cyanosis immediately following birth.

*Present Illness.*—From birth the baby breathed with a distinct wheezing sound which had become more noticeable. At one month attacks of cyanosis set in, lasting a minute or so. These increased in frequency, five attacks having occurred the day before entry. They appeared to be induced by crying or eating.

*Physical Examination.*—A well-developed and nourished child crying in distress, and extremely dyspnoeic. The dyspnoea was of the expiratory type as though there was a valve closure after inspiration. The breathing sounded asthmatic. There was an extreme expiratory grunt. The pharynx and upper respiratory passages were clear.

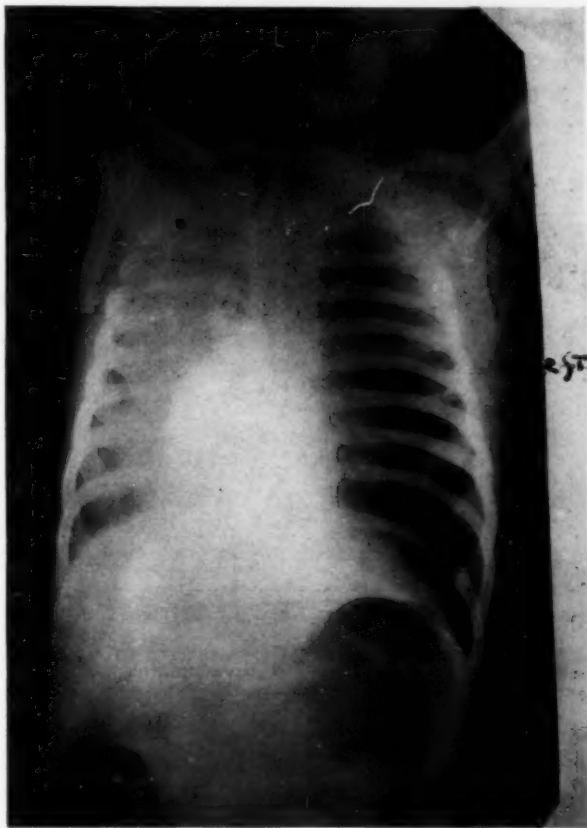


FIG. 16.—Case III. Displacement of heart and mediastinum to the right by valve type of obstruction to left primary bronchus. Expiratory bloc causes emphysema of left lung and absence of normal pulmonary markings.

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Examination of the chest showed the right lung to be less resonant than the left, there being hyperresonance on the latter side. The heart and mediastinum were displaced to the right; otherwise the examination was negative. The temperature remained normal for six days except for a terminal rise to  $102^{\circ}$  on the day of death.

The X-ray showed the left lung to be less dense than normal and the diaphragm to be low and practically immobile with the heart and mediastinum greatly displaced to the right, indicating an obstruction to expiration on the left.

The dyspnea and cyanosis became more pronounced, the child was desperately ill, and it was felt that a non-opaque foreign body might be a plausible explanation. On

bronchoscopic examination the left bronchus was found compressed to about one millimetre by pressure from without; the right bronchus was normal. There was no foreign body. The condition of the baby grew rapidly worse and respirations ceased a few hours later.

Autopsy revealed a cyst of the mediastinum with compression of the left primary bronchus. There was emphysema of the left lung and pneumonia. The heart and mediastinum were displaced to the right. There was a patent ductus arteriosus and foramen ovale. The left lung was enlarged and almost entirely covered the heart and encroached on the right pleural cavity to the costochondral junction



FIG. 17.—Case III. Drawing of post-mortem specimen. Posterior aspect. Cyst lies at bifurcation of trachea and causes compression of left primary bronchus.

of the ribs. The right lung was compressed somewhat by the mediastinum.

*Pathological Report.*—In the mediastinum there is found a small cyst measuring about one and one-half centimetres in diameter. On the posterior surface of the cyst just under the bifurcation of the trachea, is a small mass about two millimetres in diameter, of the consistency of cartilage. This cyst appears to contain transparent fluid when held up to the light. Anterior to the cyst is the left auricle and left pulmonary artery. Superior to the cyst is the patent ductus arteriosus and the arch of the aorta. The cyst is located at the bifurcation of the trachea, and is placed slightly more to the left than to the right. Posterior to the cyst is the left bronchus, on which it appears to be causing pressure, and the descending part of the thoracic aorta. The vagus nerve theoretically is found medially to the cyst and almost posterior, but is not seen during dissection. The oesophagus is also found medially and posteriorly to the cyst. Lateral to the cyst is the right bronchus. The ascending arch of the aorta is anterior to the cyst. This cyst has caused the left bronchus to be compressed so that its lumen is distinctly smaller than usual.

*Microscopically.*—This cyst is composed of fibrous tissue covered by an epithelium which in part is composed of pseudostratified, columnar, ciliated cells and a low cuboidal epithelium. This in addition covers a small mass of cartilaginous tissue. The major

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portion of the wall, however, is composed of fibrous tissue in which there is apparently but a very small amount of smooth muscle.

### COMMENT

The symptoms of cystic tumors of the mediastinum are chiefly caused by pressure. Paroxysmal cough of a brassy character, dyspnoea, and at times difficulty in deglutition or dysphagia are salient features. Pain has been frequently noted in the adult cases and hemoptysis may occur. The severity of

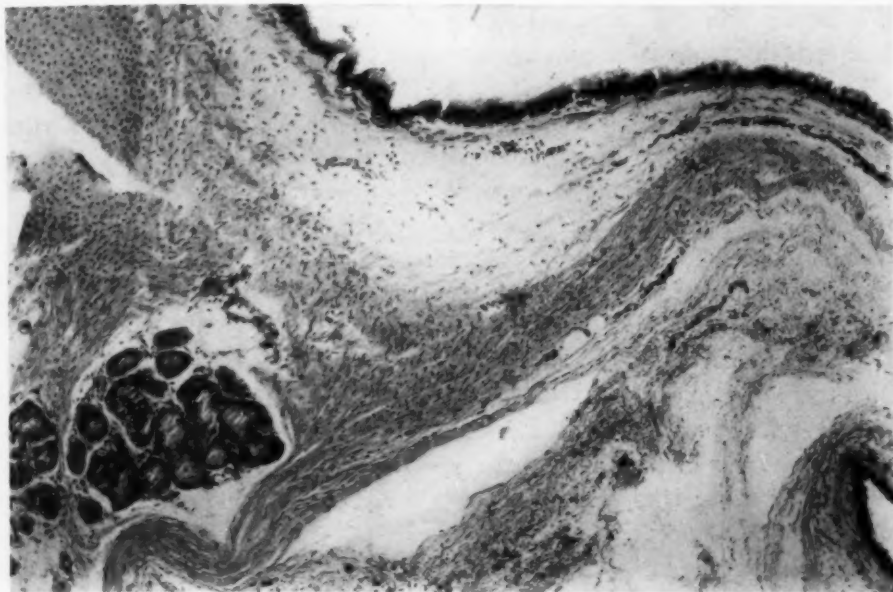


FIG. 18.—Case III. Low power. Field shows cyst lining of ciliated epithelium, mucous glands, smooth muscle and cartilage.

the symptoms does not depend on the size of the tumor. In Case III of this series, a small tumor was the cause of death from direct pressure on the left primary bronchus. The course of the disease has been divided into a latent and an active period. An intrathoracic cyst may develop slowly and insidiously to great size, and the latent period may persist throughout life without occasioning symptoms, the tumor being accidentally found at autopsy. At other times the latent period is succeeded by an active stage in which an acceleration in the progress of the disease may be provoked by an intercurrent infection such as a pneumonia. Possibly chemical changes may occur in the contents of the cyst which stimulate an increase in the rate of growth similar to the rapid tumefaction that occurs in an inflamed wen. The transition from the latent to the active stage is illustrated by Case I in our series. In other instances the latent period is absent and symptoms are manifest at birth as occurred in Case II.

The physical signs are not characteristic and may suggest empyema or unresolved pneumonia. Bulging of the chest on the affected side may be

present and there is frequently lack of expansion. There is absence of tactile and vocal fremitus over the tumor and the breath sounds are distant or absent. The heart is frequently displaced, usually by direct pressure of the tumor or secondarily, as occurred in one of our cases, by emphysema and extreme distention of the lung, due to an expiratory bloc. Emaciation or cachexia is not unusual.

In the röntgenological study of intrathoracic dermoids the visualization of a circumscribed tumor is not uncommon. In teratomata the identification of bone, teeth or calcareous deposits within the tumor is pathognomonic. In dealing with cysts of the gastrogenic or bronchogenic type, the X-ray is of less assistance. The evidence is variable. In the large tumors the film revealed a diffuse clouding of the affected side of the chest suggesting a pleural effusion. Where pressure on the bronchus from a small tumor produced an expiratory bloc, the findings were not incompatible with occlusion of the bronchus from a non-opaque foreign body. Radiographic study was of little help in the differential diagnosis. Its value lay in the definition of the size, shape and position of the cyst after aspiration of the fluid and injection of the opaque medium.

The character of the aspirated fluid assists in differentiating the dermoid from the entodermal cyst. If the material is oily yellow and contains cholesterol crystals or squamous cells, it is strongly indicative of a dermoid. The finding of hairs in the fluid or the sputum establishes the diagnosis. The secretion from the entodermal cysts was milky, mucoid and viscid. No characteristic cells were seen.

It is fascinating to speculate on the genesis of these tumors. Referring to dermoids irrespective of location, Ewing<sup>3</sup> states that "a single origin through one-sided development of teratomata cannot be excluded for the entire group." The complex dermoids are probably imperfectly developed teratomata. He believes, however, that the importance of "budding" of originally simple embryonal tissues as a source of complex teratomata has probably been underestimated. Mediastinal and retroperitoneal dermoids may be of comparatively simple structure, but it is usually difficult to refer such growths to a local origin.

In the case of the gastrogenic and bronchogenic cysts under consideration it would seem that an explanation based on the embryological development would be adequate. In the four-millimetre embryo the "lungs and trachea appear as pear-shaped masses attached to the ventral border of the œsophagus. The lower portion of the mass which bulges to each side represents the division of the trachea into bronchi. Its cavity is still in free communication with the œsophagus. The trachea will become separated from the œsophagus by downward growth of the lung buds and upward extension of the notch between the lung buds and the œsophagus."<sup>4</sup> The fusion of the lateral walls to form the tracheo-œsophageal septum begins from below.



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It would seem that at this embryonic stage, the pinching off of an outbud or diverticulum of foregut containing entoderm and mesoderm, and destined to become a portion of the stomach might well occur. This could be carried along by the downward growing lung bud and lodge in the mediastinum or on the surface of the lung. The cysts of bronchial origin might arise in a similar manner by the pinching off of a diverticulum of entoderm and mesoderm from the foregut in the region of the tracheal bud or by a secondary budding from the tracheal bud itself. The formation of these cysts takes place at a late stage of germinal differentiation while the dermoid is formed at an earlier period and the teratoma represents a primitive type of cell inclusion.

In a recently published report by Swanson<sup>5</sup> and others an intrathoracic cyst in an infant is described that is of interest in this connection. The aspirated fluid was limpid, viscid and comparable to white of egg. It contained no fat or blood. The radiographic picture of the injected cyst in the right thoracic cavity is identical with that in Case I of this series. The cyst was drained and dakinized and later formalin was injected. The histological examination of the specimen obtained at autopsy showed that the lining of the cyst was considerably disintegrated, as the result of treatment, but numerous mucous glands were identified. A submucosa, a circular and a longitudinal layer of smooth muscle and a large amount of fibrous tissue in which osteogenetic tissue was invading cartilage, were present. The presence of cartilage definitely proves it to be of bronchogenic origin, though in other respects, save for the disintegrated cyst lining, it resembles the gastrogenic cyst reported above in every particular as to its position, and gross and histological aspects. Two tumors so exactly similar though of different embryological origin could be best explained by arising through the same developmental error. The pinching off of a diverticulum at the time of the formation of the lung buds in the early embryo satisfies this requirement.

The duration is usually from one to five years following the onset of the active stage of the disease and it is obvious that surgery offers the only hope of cure in this group of intrathoracic tumors. Complete extirpation is necessarily accompanied by a high mortality and may only be accomplished after a number of stages. Many patients are in such poor condition before surgery is attempted that immediate removal of the tumor is contraindicated and drainage must be resorted to as a primary measure. This has the advantage that in large cystic tumors drainage permits the sac to shrink. On the other hand secondary infection produces a dense fibrosis, lines of cleavage are obliterated and the tumor can only be removed by sharp dissection with a greatly increased danger of injury to important structures. Beye<sup>6</sup> advocates an exploratory thoracotomy in preference to aspiration in cases of suspected dermoid. It would seem, however, that in doubtful cases aspiration was advisable to establish a diagnosis, and also to gain the information that injection of the cavity followed by X-ray will furnish, if the tumor should be cystic. Where the patient's condition permits, a complete extirpation at one sitting should be attempted in preference to preliminary drainage. In



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the eight cases of dermoid cyst reported, that were treated by this procedure, there was only one death.<sup>1</sup> Drainage or removal of the tumor was carried out in fifty-seven of the cases collected by Beye, with a mortality of 22 per cent. Recovery took place in 37 per cent., improvement in 30 per cent. and in 10 per cent. the result was not stated. Though the mortality is high, it should not be a deterrent to operation in a condition in which there is otherwise no means of palliation or cure.

### SUMMARY

Three entodermal cysts of the mediastinum are reported: two of gastro-genic origin and one of bronchogenic origin.

The symptoms and physical findings are similar to those encountered in intrathoracic dermoid and teratomatous growths in the same location.

The fluid aspirated from these cysts is white, viscid and semitransparent.

Histologically the two gastrogenic cysts present a typical section of the stomach wall. There is a mucosa with glands containing chief and parietal cells, a submucosa, two layers of smooth muscle, one circular, the other longitudinal, and in one specimen a serosa and sympathetic nerve cells.

The wall of the bronchogenic cyst is composed of fibrous tissue lined by epithelium in part ciliated. Incorporated in the fibrous tissue is a small amount of cartilage and some smooth muscle.

The genesis of these tumors may be from a pinching off of an out-bud from the foregut at the time of the development of the lung buds in the four-millimetre embryo.

The treatment of cysts of the mediastinum is preferably extirpation in one stage. Preliminary drainage may be indicated. Though the mortality is necessarily high, it should not be a deterrent in these otherwise hopeless cases.

### REFERENCES

- <sup>1</sup> Smith and Stone: *ANNALS OF SURGERY*, vol. lxxix, p. 687, 1924.
- <sup>2</sup> Kerr: *ANNALS OF SURGERY*, vol. lxxxviii, p. 607, 1928.
- <sup>3</sup> Ewing: *Neoplastic Diseases*, third ed., p. 1016, 1928.
- <sup>4</sup> Keibel and Mall: *Embryology*, vol. ii, p. 312, 1912.
- <sup>5</sup> Swanson, Platon and Sadler: *Am. Jour. Dis. Children*, vol. xxxv, p. 1024, 1928.
- <sup>6</sup> Beye: *ANNALS OF SURGERY*, vol. lxxxiii, p. 577, 1926.

DISCUSSION: DR. CARL A. HEDBLÖM of Chicago, Ill., remarked upon the importance of the differential diagnosis between such tumors and carcinoma of the lung than that of other organs. The special practical importance of the differentiation lies in the operability of the benign growths.

Dermoids of the mediastinum may simulate a variety of other conditions. He had personally observed four cases. In two cases the findings were those of chronic empyæma, in one that of a large encapsulated effusion and in one that of a pulmonary abscess. The fourth was repeatedly drained as

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for abscess. Later, wide open thoracotomy was performed to determine the reason for the persistent drainage. Stratified epithelium was found in the wall of the abscess and hair in the cavity.

DR. CHARLES G. MIXTER (closing the discussion) said, in regard to mortality and the statistics as previously published, that in the cases reported last year by Kerr eight instances of primary extirpation of tumor were reported with one death. Some years before fifty-eight operated cases had been reported with a recovery of 37 per cent.; another 30 per cent. of cases improved. In other words, these cases should offer a fairly hopeful field for radical surgery.

## PARATHYROIDECTOMY IN OSTEOMALACIA

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AND

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THE extent to which disturbance of endocrine function may underlie generalized diseases of the skeleton has long been a matter of interest. With the clearer appreciation of the physiology and clinical importance of the parathyroid glands, made possible through the availability of a potent parathyroid extract as a result of the work of Collip<sup>1</sup> and others, this relationship takes on a new importance.

The osseous framework of the bones is clearly not a static structure, but one with an active metabolism readily changing even in adult life according to disuse or activity, or in response to demands made upon it through variations in the inorganic salt metabolism of the body. Clinically the relationship of osteomalacia to repeated pregnancies and lactation or to an abnormal diet is well known. That bone atrophy may occur in response to the increased calcium and phosphorus metabolisms in thyrotoxicosis has been demonstrated.<sup>2, 3</sup> Decalcification of bones may be brought about by the long continued administration of Collip's parathyroid extract.<sup>4, 5</sup> The cancellous bone serves as the most readily available supply of body calcium in response to the metabolic demands made by this hormone. The shafts have a slow progressive exchange of inorganic salts, and are not influenced except in the case of unusual body demands.<sup>5</sup>

The association of pathological changes in the parathyroids with generalized diseases of the skeleton is well known. It may be sufficient here to present the findings of Hoffheinz<sup>6</sup> who was able to collect from the literature forty-four cases of enlargement of the parathyroid glands found at autopsy, usually of the nature of hyperplasia. He also presented in detail one case of his own. Among these cases, skeletal disease was described twenty-seven times. Osteitis fibrosa occurred seventeen times, osteomalacia eight, and rachitis twice. The theory which had been commonly accepted to account for this relationship explains the enlargement on the basis of a compensatory hypertrophy as a consequence of the unusual demands made upon the parathyroid apparatus through the excessive calcium metabolism brought about by the skeletal disease. Hoffheinz<sup>6</sup> points out that certain facts are in disagreement with this theory. In a great number of cases both

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of osteitis fibrosa and of osteomalacia, pathological changes in the parathyroids are not found, although the demands of excessive calcium metabolism are present. Again when parathyroid enlargements do occur, in 85 per cent. of the cases only one gland of those present is affected, a finding difficult to explain on the basis of compensatory hypertrophy. On the other hand, it is more likely that the enlargement of the parathyroids is the cause and not the consequence of an abnormal calcium metabolism, and hence of the skeletal disease. (Simmonds,<sup>7</sup> Mandl,<sup>13</sup> Gold,<sup>16</sup> Barr.<sup>17</sup>)

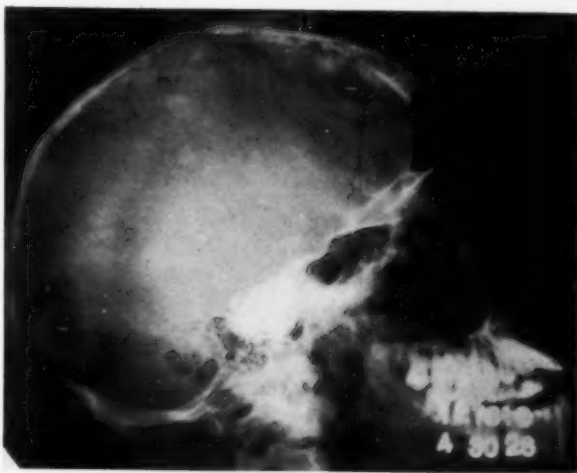


FIG. 1.—Skull. X-ray of head, showing malocclusion of teeth, changes in the calvarium, and enlarged sinuses.



FIG. 2.—Thorax. X-ray of thorax, showing abnormal curvature of ribs.

We are greatly indebted to Dr. E. F. Du Bois, who referred the following patient to the Massachusetts General Hospital for continuation of metabolic studies undertaken at the Russell Sage Institute of Pathology at the Bellevue Hospital, New York. Doctor Du Bois's observations showed so great a variation from the normal in calcium and phosphorus metabolism that he suggested that the patient represented an instance of hyperparathyroidism. The clinical history and metabolic studies of this case will be presented in detail elsewhere.<sup>8, 9</sup>

The important points follow: The patient, a master mariner, thirty-four years of age, was admitted to the hospital April 24, 1926. Up to 1918 he was an athletic man in perfect health, six feet one inch tall and weighing 185 pounds. He ate a well-balanced diet, except for a short time in 1918, when there was a deficiency of calcium in his diet. His trouble began about June, 1919, and was characterized by pains in the knees, hips and sacral region. About six months later he became noticeably pigeonbreasted. His height progressively diminished to five feet six inches. Muscular weakness and clumsiness gradually developed. He was forced to give up work, and eventually became almost completely incapacitated. At times he had urinary frequency, occasionally with the passage of white gravel. During these years he had seven fractures, caused usually by slight injury.



FIG. 3.—Hip. Upper right femur, showing largest bone cyst, and disappearance of cancellous and cortical bone.

Examination showed an alert, intelligent man in good color and state of nutrition, apparently organically sound, aside from the changes in the skeleton. The chief of these were a general forward bowing of the spine, with obliteration of the lumbar curve, a barrel-shaped chest, the lower ribs almost impinging on the iliac crests, shortening of the neck, and malocclusion of the teeth. The extremities showed no obvious deformity aside from bowing of the left forearm from the previous fractures.

On röntgenological examination, practically all the bones showed a diminution of bone salts and rather coarse trabeculae. All the vertebrae showed atrophy, the lumbar vertebrae particularly; these appeared compressed. The pelvis was narrower than usual. Proliferative changes were found about each sacroiliac joint. There was considerable atrophy of the femora with thinned cortex and slight lateral bowing. In the upper part of the right femur there was a cyst-like area about three centimetres in the greatest diameter. Two similar areas, about one centimetre in diameter, were found in the left femur. The bones



FIG. 4.—Left femoral shaft. X-ray of femoral shaft, showing increase in cortical bone, two years after operation. (Left.)

of the arms showed similar atrophy with a few cyst-like areas in the humeri. Bony union had occurred at the sites of the fractures. Atrophy had led to retraction and abnormal curvature of the ribs. The calvarium was thickened and mottled in the frontal region, and thinner than normal posteriorly. The sinuses were enlarged; the sella turcica normal in size and contour. (See Figs. 1, 2 and 3.)



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The diffuse character of the changes in the bones on Röntgen-ray examination would suggest the inclusion of this case under the general heading of osteomalacia, although cystic cavities similar to those described as osteitis fibrosa were present.

The evidence in favor of hyperparathyroidism in this case may be brought out by contrasting the effect of parathyroid extract with the changes occurring in parathyroid tetany. If a potent parathyroid extract is administered, there results a rise in the serum calcium, a rise in the urinary calcium excretion, a fall in the serum phosphorus, and a rise in the urinary phosphorus excretion.<sup>10, 11</sup> If the administration of such an extract be continued for a sufficient period of time there results decalcification of the bones easily demonstrated by X-rays. With deficiency of the parathyroid glands the converse results, a fall in the serum calcium, a fall in the urinary calcium excretion, and a rise in the serum phosphorus, and a fall in the urinary phosphorus excretion.<sup>12</sup>

Calcium and phosphorus metabolism studies in this case revealed the following:<sup>9</sup>

1. A markedly elevated serum calcium (13.1 to 15.3 milligrams per 100 cubic centimetres as compared to a normal serum calcium of 9.5 to 10.5 milligrams per 100 cubic centimetres).

2. A markedly increased calcium excretion due entirely to an increased urinary calcium elimination. The urinary calcium excretion was six to seven times greater than was found in fifteen normal individuals studied under identical conditions.



FIG. 5.—Lower leg and foot. X-ray of lower leg and foot showing increase in cortex, and in definiteness of trabeculae. Plates taken April 4, 1926, and June 13, 1928. (Right.)

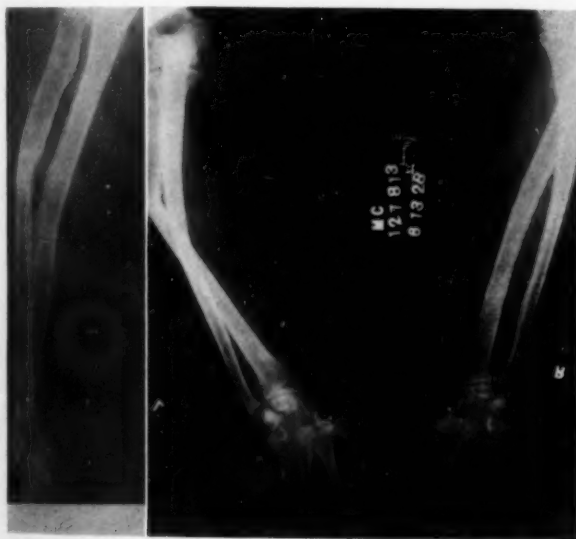


FIG. 6.—Arms. X-ray of arms, April 28, 1926, and June 13, 1928. (Right.)

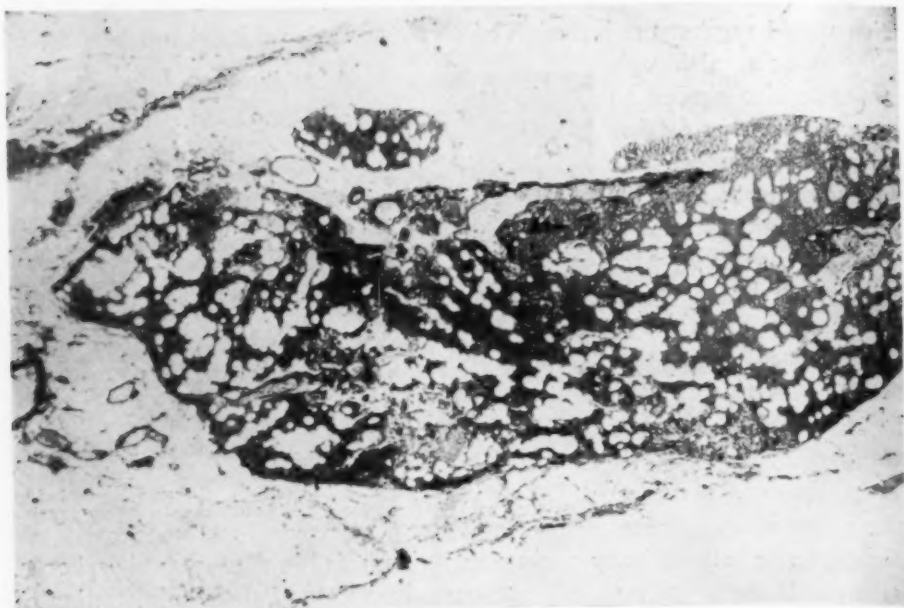


FIG. 7.—Right parathyroid; low power.

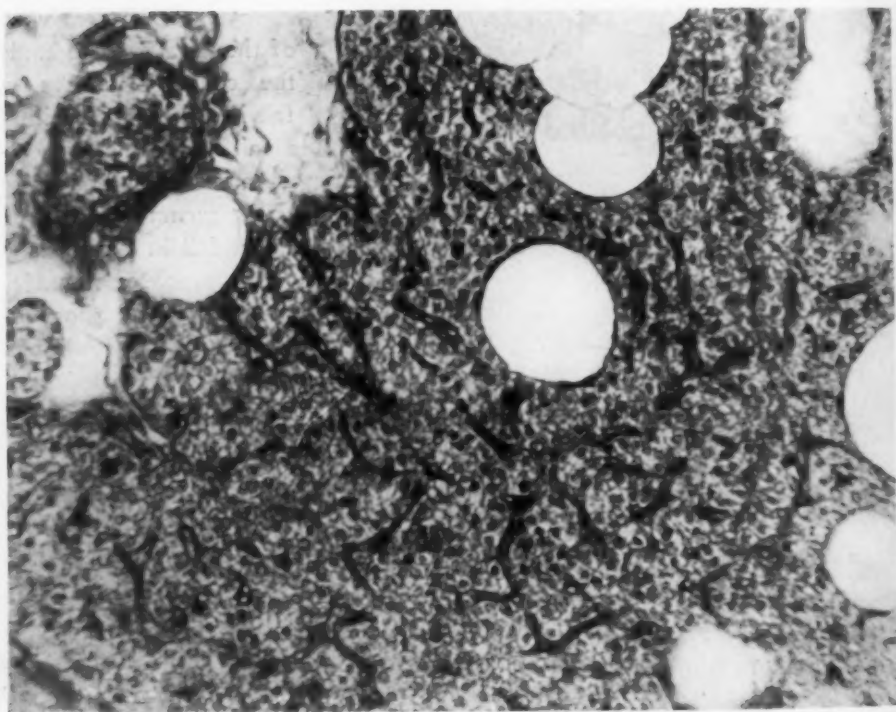


FIG. 8.—Right parathyroid; high power.

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3. A considerably reduced serum phosphorus (1.4 to 3.2 milligrams per 100 cubic centimetres as compared to a normal serum phosphorus of 3.5 to 4.5 milligrams per 100 cubic centimetres).

4. An increased phosphorus excretion.

The changes in the calcium and phosphorus metabolism observed in this case were approximately the equivalent of those found in a normal individual while receiving 100 units of Collip's parathyroid extract a day.

On account of these abnormal metabolic findings it seemed reasonable to conclude that this patient was suffering from an increased function of the

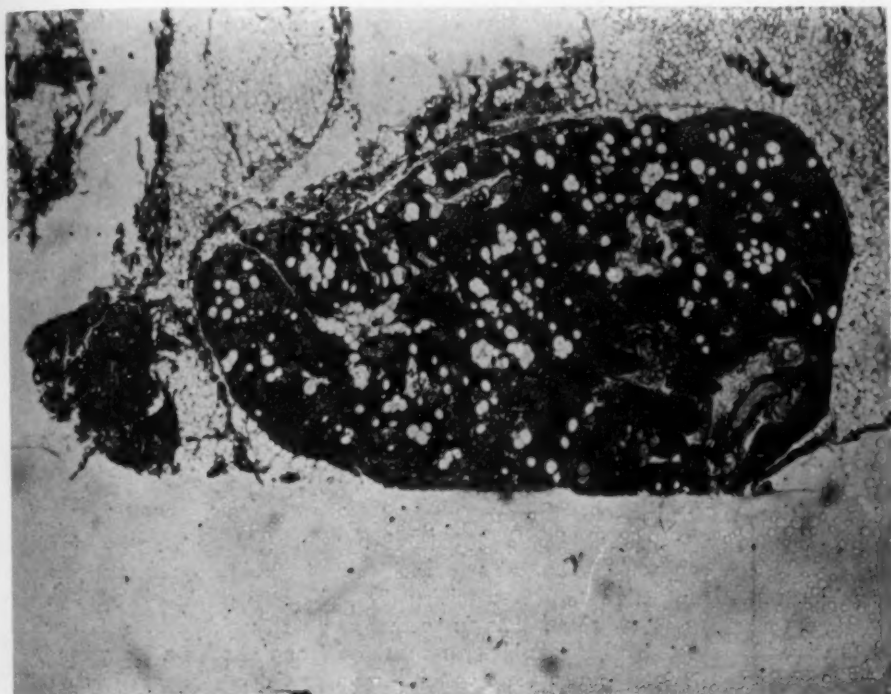


FIG. 9.—Left parathyroid; low power.

parathyroids, or hyperparathyroidism, and that his osteomalacia was secondary to the abnormal loss of calcium so produced. For this reason operation was offered, and was readily accepted. Because of the pathological association of bone disease with parathyroid change previously mentioned, it was supposed that an adenomatous enlargement of a parathyroid gland might be present, although the thyroid was barely palpable and no tumor in the neck could be felt. If such were the finding, it would be excised; if no tumor were found, one parathyroid would be removed. At the time we had no knowledge of an operation on the parathyroids having been undertaken with a view to reducing calcium loss from the bones, although Mandl's preliminary report had appeared.<sup>13</sup>

Operation was undertaken May 17, 1926, under ethylene anaesthesia. We were apprehensive that struggling during induction of an anaesthetic might lead to further fractures. The right lobe of the thyroid was exposed, freed and turned inward. Close to the inferior

artery, in the expected position, a structure resembling a normal inferior parathyroid gland was found and removed. On microscopic examination, however, it later proved to be normal thyroid tissue. An encapsulated lobule of yellow fat, receiving its blood supply through a twig from the inferior thyroid artery, was displaced together with the thyroid lobe, and seemed intimately connected with the thyroid capsule. This fat proved on section after removal to enclose a normal parathyroid gland. (See Figs. 7 and 8.) The superior parathyroid was not seen.

Following the operation no appreciable change in metabolism resulted. Accordingly exploration of the other lobe of the thyroid was suggested, with a view to removing another parathyroid, and was undertaken June 11, 1926. On exposure of the posterior surface of this lobe, no structure resembling a parathyroid gland was found. However, in view of the experience on the other side, five yellow lobules of fat were removed; one of these, situated close to the inferior thyroid artery, proved to enclose, on microscopic examination, a parathyroid gland normal in structure aside from fatty infiltration, similar to the one previously removed. (See Fig. 9.)

*Microscopic examination* of these two parathyroids, by Dr. Tracy B. Mallory, showed: (1) May 17, 1926: A longitudinal section of a parathyroid gland. It is not enlarged. The stroma contains numerous large fat cells. The glandular substance itself is not atypical. The epithelial cells show a distinct alveolar arrangement and occasionally surround droplets or larger masses of colloid-like material. The majority are of the "clear" vacuolated type. Usually from one to two of the "oxyphile" cells are present in each alveolus. These show a larger amount of cytoplasm than the "clear" cells. They are unvacuolated and are filled with one eosinophilic granule. The proportion of these cells to the "clear" ones is about one to eight. No mitotic figures are found.

*Diagnosis.*—Normal parathyroid gland.

(2) June 12, 1926: A section of a parathyroid gland. It is not abnormal in any way and the proportions of "clear" and "oxyphile" cells are essentially the same as in the specimen removed one month previously. The absence of histologic evidence of hyperplasia in no way rules out the possibility of physiologic overactivity. (Aschoff.)

*Diagnosis.*—Normal parathyroid gland.

At the time, we felt that even if a parathyroid deficiency resulted, we had in Collip's parathyroid extract a means of combating it indefinitely, comparable to the use of insulin in diabetes. However, it has since become apparent that parathyroid extract, as at present supplied, may lose its effectiveness.<sup>11</sup> Recognizing the seriousness of chronic tetany, and the great difficulty in alleviating its effects, in another case we should hesitate to run the risk of serious damage to the parathyroid apparatus through so extensive a dissection.

Following this second operation there was still no appreciable difference in the calcium and phosphorus metabolism. However, the patient had shown greater ability to retain calcium on a diet high in calcium, and evidence of this calcium retention was present in the bones on Röntgen-ray previous to discharge October 9, 1926.

Since this time the patient has done well, and has progressively improved, so that on June 11, 1928, when last seen, he stated that he felt very well, was able to get about without difficulty, and had been working for ten months. Röntgen-rays taken for comparison with previous plates showed a marked increase in the amount of calcium deposit in his bones.\* (See Figs. 5, 6 and 7.)

We have very little evidence that removal of two parathyroid glands contributed in any way to this result. We should like to stress the importance

\* A letter dated May 4, 1929, from the patient states that he has been working in an office since October 15, 1927. He walks a mile and a half a day in the course of his duties, and feels well aside from easy fatiguability and soreness of muscles after unusual exertion. He has had no further fractures, although he incurred two bad falls during last winter.



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of a diet high in calcium and in phosphorus, particularly the latter, under conditions where it is apparent that there is a drain of calcium from the body.<sup>9</sup> While remissions occur during osteomalacia, and spontaneous cures may rarely take place, a result such as in this case is very unusual.

The experience of others in removing parathyroid tissue supports the idea that increased function of the parathyroids may underlie changes in the skeleton with loss of calcium from the bones.

The first case in which operation was undertaken is that of Mandl<sup>14</sup> who reports a case of generalized osteitis fibrosa in a man, thirty-eight years of age, for which parathyroidectomy was performed. This patient had an increasing disability with pain in the bones during five years, eventually causing him to be bedridden. The transplantation of four human parathyroids resulted in no benefit. Four weeks later, July 30, 1925, the thyroid region was explored and a tumor of the left lower parathyroid, twenty-five by fifteen by twelve millimetres in size, was removed. The other parathyroids appeared normal. The daily urinary calcium excretion before operation was 54 milligrams; on the eleventh day after operation, on a similar diet, it was 7.6 milligrams. Four months after operation the patient was subjectively improved. His pain had diminished, he had gained weight and was able to walk with a crutch and cane. Two and a half years after operation,<sup>15</sup> he had gained sixteen kilograms in weight, and was able to walk with a cane. Complete recovery had not occurred.

Mandl<sup>14</sup> operated on a second case of generalized osteitis fibrosa in a man, forty-four years of age, with a three years' history of increasing disability which eventually confined him to bed. However, the urinary calcium excretion of this patient was within normal limits. His blood calcium was 12.5 milligrams. No parathyroid enlargement was found at operation, but one parathyroid which showed fatty degeneration only was removed. The patient showed slight subjective improvement six weeks after operation, but this could not be confirmed objectively. Mandl suggests that the presence or absence of an abnormal calcium metabolism will give us information as to the presence or absence of a parathyroid tumor.

Gold<sup>16</sup> reports the case of a woman, fifty-four years of age, who gave a history of progressive disability during three and one-half years, accompanied by pain. Röntgen-ray examination showed the changes of generalized osteitis fibrosa. No tumor could be felt in the neck. At operation, July 20, 1927, a small thyroid was exposed. On turning the right lobe inward, a tumor-like enlargement of the upper parathyroid, in size twenty-five by sixteen millimetres, was exposed and removed; this was microscopically a benign adenoma. Following operation the blood calcium fell from 13.1 milligrams to normal, the daily urinary excretion of calcium, previously twice normal, fell to about one-third of the normal value. The patient was subjectively greatly improved following operation; the pain was much relieved; she could attend to her housework and she had gained eleven kilograms in weight when last heard from, six months after operation. However, an improvement in the diseased bones could not be established röntgenologically.

Barr and others<sup>17</sup> have reported an instance of hyperparathyroidism occurring in a woman, fifty-six years of age. This patient, who habitually used an unbalanced diet, developed urinary symptoms and an increasing difficulty in walking which led to total disability. Examination showed a remarkable degree of muscular hypotonia, bilateral nephrolithiasis, changes in the bones—tumors of a finger, of the ulna, and of the maxilla, and sufficient rarefaction of the bones to justify the diagnosis of osteomalacia. The tumors of the finger and of the ulna showed the microscopic appearance of giant-cell sarcoma. The blood calcium was 16 milligrams and the metabolic studies showed a constant negative calcium balance, with a loss of calcium which became greater with any increase of calcium in the diet.

A nodule the size of a small walnut could be felt in the left lobe of the thyroid. This



was removed, and proved to be a parathyroid adenoma. The patient developed tetany two days later, from which she partially recovered under treatment. The blood calcium became lower than normal; she retained large amounts of calcium; the tumor on the jaw became smaller, and the teeth which had been loosened over the area of the tumor became tightened.

From these experiences it would seem clear that given generalized disease of bone, with loss of calcium not otherwise explainable, whether of the type of osteomalacia, osteitis fibrosa, or of some similar condition, particularly if accompanied by muscular weakness, overactivity of the parathyroids should be suspected. Here an estimation of the blood calcium and the loss of calcium in the urine is particularly desirable. If these chemical findings are similar to those produced by parathyroid extract, such as an increase in the blood calcium and excessive loss of calcium in the urine, this suspicion is given additional weight. This loss of calcium should be combated, as in the case of bone changes from an unbalanced diet or repeated pregnancies, by a diet high in calcium and phosphorus. If the patient is unable to store calcium under this régime, operation for removal of the parathyroid tissue should be considered. This indication is clearer if a nodule suggestive of a parathyroid tumor is palpable. However, in neither of Mandl's nor Gold's cases, where such a tumor existed, was it felt before operation.

The case here reported, as an example of hyperparathyroidism, is incomplete in two respects. In the first place, the two parathyroids removed showed no microscopic evidence of overactivity. In the second place, their removal exerted little effect on the inorganic salt metabolism. It is of course possible that a tumor of an aberrant parathyroid was overlooked. However, the metabolic findings were consistent with overactivity of the parathyroid glands, and the development of bone atrophy is adequately explained on this basis.

#### CONCLUSIONS

1. Generalized skeletal disease with disappearance of salts from the bones may be explained in certain instances on the basis of overactivity of the parathyroid glands.
2. In order to justify a diagnosis of hyperparathyroidism in an individual, there must exist marked decalcification of the bones, muscular hypotonia, an elevated serum calcium, an increased calcium excretion, a reduced serum phosphorus and an elevated phosphorus excretion.
3. When excessive calcium loss from the body is not explainable on any other ground, and cannot be combated in any other way, exploration of the parathyroid glands, with a view to removing parathyroid tissue, is justifiable.

#### BIBLIOGRAPHY

- <sup>1</sup> Collip, J. B.: The Extraction of a Parathyroid Hormone Which Will Prevent or Control Parathyroid Tetany, and Which Regulates the Level of the Blood Calcium. *Jour. Biol. Chem.*, vol. lxxiii, p. 395, 1925.
- <sup>2</sup> Aub, J. C., Bauer, W., Ropes, M. W., and Heath, C.: The Relation of the Thyroid Gland to Calcium Metabolism. *Trans. Assoc. Am. Physicians*, vol. xliii, p. 344, 1927.

## PARATHYROIDECTOMY IN OSTEOMALACIA

- <sup>3</sup> *Do*: Studies of Calcium and Phosphorus Metabolism: III, The Effect of the Thyroid Hormone and Thyroid Disease. *Jour. Clin. Invest.*, vol. vii, April, 1929.
- <sup>4</sup> Bauer, W., Albright, F., and Aub, J. C.: The Source of the Readily Available Body Calcium. *Jour. Clin. Invest.*, vol. iv, p. 444, 1927.
- <sup>5</sup> Bauer, W., Aub, J. C., and Albright, F.: Studies of Calcium and Phosphorus Metabolism: V, A Study of the Bone Trabeculae as a Readily Available Supply of Calcium. *Jour. Exp. Med.*, vol. xlix, p. 145, 1929.
- <sup>6</sup> Hoffheinz: Über Vergrößerung der Epithelkörperchen bei Osteitis fibrosa und verwandten Krankheitsbildern. *Virch. Arch. f. path. Anat. und Phys.*, vol. cclvi, p. 705, 1925.
- <sup>7</sup> Simmonds: *Med. Klin.*, 17, vol. ii, p. 1374, 1921.
- <sup>8</sup> Du Bois, E. F., McClellan, W. S., Hannon, R. R., and Shorr, P.: to be published.
- <sup>9</sup> Bauer, W., and Aub, J. C.: Studies in Calcium and Phosphorus Metabolism: VI, A Case of Osteomalacia with Evidence of Hyperactivity of the Parathyroid Bodies. *Jour. Clin. Invest.* In press.
- <sup>10</sup> Greenwald, I., and Gross, J.: The Effect of Long-continued Administration of Parathyroid Extract upon the Excretion of Phosphorus and Calcium. *Jour. Biol. Chem.*, vol. lxxviii, p. 325, 1926.
- <sup>11</sup> Albright, F., Bauer, W., and Aub, J. C.: Studies of Calcium and Phosphorus Metabolism: IV, The Effect of the Parathyroid Hormone. *Jour. Clin. Invest.*, vol. vii, April, 1929.
- <sup>12</sup> Ellsworth, R. M., and Albright, F.: Studies in the Physiology of the Parathyroid Glands. *Jour. Clin. Invest.* In press.
- <sup>13</sup> Mandl, F.: Therapeutischer Versuch bei einem Fall von Osteitis fibrosa generalisata mittels Exstirpation eines Epithelkörperchen tumor. *Cent. f. Chir.*, vol. liii, p. 260, 1926.
- <sup>14</sup> Mandl, F.: Klinischer und experimentelles zur Frage der lokalisierten und generalisierten Osteitis fibrosa. *Arch. f. Klin. Chir.*, vol. cxliii, pp. 1-245, 1926.
- <sup>15</sup> Mandl, F.: Discussion. *Wien. med. Woch.*, vol. lxxvii, p. 1734, 1927.
- <sup>16</sup> Gold, E.: Ueber die Bedeutung der Epithelkörpervergrößerung bei der Osteitis fibrosa generalisata Recklinghausen. *Mitt. a. d. Greuz., d. Med. und Chir.*, vol. xli, p. 63, 1928.
- <sup>17</sup> Barr, D. P., Bulger, H. A., and Dixon, H. H.: Hyperparathyroidism. *Jour. Am. Med. Assn.*, vol. xcii, p. 951, March 23, 1929.

DISCUSSION: DR. CHARLES L. GIBSON of New York City described a case admitted to the New York Hospital in the service of Dr. Lewis A. Conner and worked up by Doctor Foster. The case is described as one of hypercalcemia. The history is as follows:

A woman, fifty-seven years of age, was admitted to the New York Hospital complaining of pain in the anterior portion of the chest and in the sacro-iliac region, of three months' duration. The past history was essentially negative and there were no other symptoms except a loss of twenty pounds in weight during the three months previous to admission. She was a fairly well-developed and well-nourished woman with evidence of a secondary anemia. No other positive findings were elicited except for a thickening of the interphalangeal joints and a limitation of motion of the spine, due to bony changes. *X-ray examination* showed an extensive hypertrophic osteo-arthritis involving the spine, with a partial decalcification of the dorsal and lumbar vertebrae and the iliac bones. *Laboratory findings.* Nothing abnormal except a mild secondary anemia. Examination of blood showed

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the calcium to be elevated to 15.3 mgm. per 100 c.c. on admission. Five days later the blood calcium was 17.1 mgm. per 100 c.c.

During the two weeks after admission extensive studies were made on the patient and no other pathology was found. The patient began to have attacks of vomiting which increased in severity and in frequency until at a time two weeks after admission she was unable to take even fluids by mouth. Blood calcium determination at this time was 18.7 mgm. per 100 c.c. The severe vomiting continued and it became necessary to combat the dehydration with numerous hypodermoclyses and infusions. Blood calcium during the third week after admission reached 19.4 mgm. per 100 c.c. and 18.2 and 18.6 mgm. per 100 c.c. during the fourth week. Vomiting and dehydration increased and the patient became weaker, although the temperature remained about normal throughout the illness. Transfusion was done with no avail.

Seven weeks after admission the blood calcium was found to be 15 mgm. per 100 c.c. and at this time parathyroidectomy was advised. At operation three parathyroids were removed under ethylene anaesthesia.

Immediately following the operation there was little or no reaction. The patient became progressively weaker, however, and died eighteen hours post-operative. There were no signs of tetany at any time. Pathological examination of the excised parathyroid glands showed the glands to have undergone evident regressive changes. Post-mortem examination was refused.

NOTE: No parahormone treatment given.

DR. FRANK H. LAHEY of Boston, Mass., said that sometime ago, he suggested that all parathyroid glands found on removed thyroid specimens be immediately transplanted, and published a description of a method and his experiences with it. He had now transplanted over three hundred bodies which at least had the possible appearance of parathyroids. Before transplanting these suspected bodies, a section has been taken from each one and sent to the pathologist, and of these transplants, but one hundred have been proven microscopically to be parathyroids.

Doctors R. B. Cattell and R. L. Mason, working in the Clinic, have done thyroparathyroidectomy upon dogs with immediate grafting of one parathyroid gland into the sternomastoid.

Sometime ago, Doctor Halstead demonstrated the feasibility of reimplantation of removed parathyroids, and in this experiment Doctors Cattell and Mason have gone a little further. They first demonstrated that the animal had a normal blood calcium, then removed all of the parathyroids, reimplanting one in the muscle, and produced clinical tetany and a drop in blood calcium. The animal was then carried on parahormone for two weeks while the graft was taking, and at the end of this time (two weeks), parahormone was discontinued without a return of tetany and without a drop in blood calcium. The dog was allowed to live for three months during which time there was no tetany and at the end of this time, the graft was excised from the sternomastoid with the immediate appearance of tetany, a drop in blood calcium, and the demonstration of the living parathyroid graft in the muscle. Doctor Halstead has demonstrated that these parathyroid grafts will not take unless all of the parathyroids have been removed and a parathyroid deficiency is present.

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In view of the above, he believed in the cases described by Doctor Richardson, which must necessarily be rare, if removal of two and certainly three of the parathyroids be done, it would be a wise provision to transplant one of them into the sternomastoid. If, then, all of the parathyroids have been removed, the deficiency will permit the grafted parathyroid to take and thus prevent tetany, and if no deficiency be present, the graft will not take and a subtotal parathyroidectomy will have been accomplished safely.

DR. GEORGE W. CRILE of Cleveland, Ohio, said that surgeons had had more trouble than they should have in getting successful transplants of the parathyroids. The transplants haven't always grown. Lately, he had taken the precaution to cut out a small amount of the thyroid itself right around the parathyroid so that the new implantation is associated with its old friend, the thyroid. Those transplants in which this has been done apparently have done well.

## PAROXYSMAL HYPERTENSION ASSOCIATED WITH TUMOR OF THE SUPRARENAL

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THIS report has to do with *paroxysmal hypertension* associated with *tumors of the medulla of the suprarenal body*. The patient whose case is reported was referred to me by Dr. Maurice C. Pincoffs, who reported the point of view of diagnosis and clinical aspects before the Association of American Physicians on May 8. Portions of the tumor after removal were used for experimental work by Dr. William H. Shultz, and the three of us will publish a full report of all phases of the case later.

We are not concerned in this report with tumors of the suprarenal cortex. The medulla of the suprarenals is a part of the chromaffin system which is not confined to the suprarenal body. The two portions of the suprarenal, cortex and medulla develop from entirely different tissues; the cortex develops from the mesoderm. "The immediate anlage of the suprarenal medulla and the anlages of the remainder of the chromaffin organs lie in the sympathetic ganglions, which, in turn, are derived from the cells of the neural crest." These primitive cells of the ganglions are called sympathogonia or the sympathetic formative cells. In early fetal life these cells migrate laterally toward the suprarenals. "During the migration, portions of the embryonic tissue may become split off; these develop as separate organs at varying distances from the aorta in the region of the renal arteries or the inferior mesenteric artery to form the organs of Zuckerkandl."

The first report of a tumor of the medulla of the suprarenal body was by Berdez,<sup>1</sup> in 1892. That these tumors may be associated with hypertension was pointed out by Neusser,<sup>2</sup> in 1898, who reported two tumors of the adrenals described by him as carcinoma. Vaquez,<sup>3</sup> in 1904, associated hypertension with increase of epinephrin in the blood. No one has proven, up to the present, that an increase of epinephrin is found in the blood in patients with hypertension. Many clinical observations in patients with chromaffin cell tumors of the suprarenal glands indicate that this is true, but the proof is not forthcoming.

Oppenheimer and Fishberg<sup>4</sup> give three varieties of tumors derived from the medulla of the suprarenal.

1. Sympathoblastomas, made up of immature sympathoblasts.
2. Ganglioneuromas, consisting of relatively mature sympathetic ganglion cells.
3. Paragangliomas, which is the type of tumor with which we are concerned in this paper. These are rare tumors and Rabin<sup>5</sup> was able to find only thirty cases in the literature, and in an excellent article in the *Archives of Pathology* for February, 1929, he discusses these cases and reports one of his own.



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These tumors of the medulla of the suprarenal body have been given different names—perithelioma, paraganglioma, chromaffin cell tumors and pheochromocytoma. They were formerly considered as types of sarcoma, but it is now known that the majority of them are benign and encapsulated. Of the thirty tumors of medulla of the suprarenals many had associated with them hypertension, instability of the vasomotor system or glycosuria. Only three of them, however, showed paroxysmal hypertension. We mean by this that at irregular intervals the blood pressure will rise sharply 100 or more points above the normal and these rises will be accompanied by heart consciousness, rapid pulse, flushing, nausea or headache and that after a few hours' interval the pressure will return to normal.

We have been able to find in the literature only three cases of paroxysmal hypertension associated with chromaffin tumor of the suprarenal. The first case reported was by L'abbé, Tinel and Doumer.<sup>6</sup> This patient had attacks of paroxysmal hypertension associated with œdema of the lungs and in one of these attacks she died. Autopsy disclosed a tumor of the medulla of the left suprarenal.

The second case was reported by Oberling and Jung.<sup>7</sup> This patient was a woman, twenty-eight years of age, with a normal pregnancy and delivery in 1922. In 1927, close to term in a second pregnancy, she was found by her physician to have a pressure of 250/190, with well-marked albuminuria and severe headaches. The following day in hospital her pressure had fallen to 180/150, and in the ensuing few days the pressure was quite variable between about 170/110, and 220/155. She delivered normally, but went into a state of shock two hours after delivery with a pressure of 130/120, and a pulse of 150. She died in this condition a few hours later. At autopsy a kidney-sized, encapsulated tumor was found replacing the left adrenal. The histological structure identified it as a paraganglioma.

The third case was reported by Dr. Charles H. Mayo.<sup>8</sup> This patient was having attacks of paroxysmal hypertension and exploratory laparotomy was done, because it was thought that some pathology of the splanchnic nerves might be responsible for the attacks and because there was abdominal pain. A tumor was found that was retroperitoneal, behind the tail of the pancreas and impinging upon the upper pole of the left kidney. Doctor Mayo reported in addition to the tumor which was removed that the left suprarenal body was twice its normal size and that the right one was apparently slightly enlarged. The patient recovered and the symptoms disappeared. The microscopic diagnosis was retroperitoneal malignant blastoma.

Another case was reported which was not confirmed by either operation or autopsy, but it seems probable that the clinical diagnosis of paraganglioma was correct. Vaquez and Donzelot<sup>9</sup> reported this case in 1926. A young man, thirty-seven years of age, who showed very striking attacks of paroxysmal hypertension. The authors, on purely clinical grounds, were led to the belief that this was a case of suprarenal paraganglioma, similar to the one reported by L'abbé, Tinel and Doumer. The patient left their service, however, and later came into the care of Laubry,<sup>10</sup> who reported the outcome in a separate article in 1927. Laubry, accepting the clinical diagnosis of Vaquez, subjected the patient to deep X-ray treatment over the adrenals with the result that the attacks diminished and finally disappeared entirely and had been absent for six months at the time of his report.

CASE REPORT.—The subject of this report came to see Doctor Pincoffs because of "attacks with palpitation of the heart." She was twenty-six years old, had been married one year, with no pregnancies. She had always been very active with a sanguine temperament. At this time a sister had a mass in the upper chest, which interfered with breathing and caused distention of the neck vessels.

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Ten years before, when she was at school, she suffered at about weekly intervals with attacks of flushing and warmth in the right arm, associated with a sudden feeling of being shaky and nervous. She thought these attacks were brought on by playing basketball. They were brief in duration and after a few months they disappeared. After three or four years the attacks returned, but somewhat different in nature. They would begin with a hot, flushed feeling in both arms followed by a sensation of tightness and compression over the heart, which would beat forcibly. There was a feeling of difficulty in breathing and of swelling of the neck. After some time, nausea would appear and if she forced herself to vomit, some relief of symptoms would be obtained. The vomitus contained whatever might be in the stomach.

At first the attacks were infrequent, but gradually the interval between them shortened. They occurred at any time, but rarely late at night. She could not make out that any particular act of hers precipitated the attacks. They had a tendency to recur at about the same hour each day. She usually had at least one attack daily and sometimes, when the paroxysm was a light one, there would be a severe attack in the evening.

When she came in the hospital for study, the attacks were increasing in violence and frequency and severe occipital headache was an increasingly troublesome symptom. She had been in the habit of going off to herself and sitting quietly through the attacks. Afterward she felt entirely well. During the attacks there would be some apprehension, because of the symptoms, especially the sense of constriction and difficulty in breathing, the forceful heart action and a shaky, nervous feeling.

In addition to these symptoms there were frequent attacks of diarrhoea and vomiting, without fever. Her habits were negative, except for excessive cigarette smoking. During the preceding year she had had swelling in both parotid regions a number of times, which came on suddenly, was painless and without fever. This swelling would persist several weeks. In the first attack it was diagnosed mumps.

The physical examination was negative. The chest was clear. The heart was normal in position and size, sounds clear, good rhythm, pulse rate normal, blood pressure 120/90. Abdomen negative. Blood count normal. Wassermann negative. Stool normal. Two specimens of urine were examined, both showed a trace of albumen and one a definite reduction for sugar, confirmed by fermentation.

The patient was next observed in an attack. It was found that as soon as symptoms were complained of the blood pressure was already 190/98. It rose gradually to 219/110, and in the next half hour fell to 176/76. During the height of the attack there was marked pulsation of the vessels of the neck, the jugulars were prominent, the hands, feet, knees and nose were quite cool to the touch, the face a little flushed, there was marked tremor of the hands, the respirations were shallow and increased to 36, and the pulse rose gradually to 110, and fell to 76, with the fall in pressure.

A number of similar attacks were observed. It was proved that between the attacks the pressure was always normal. In one paroxysm the systolic pressure rose above 260, beyond where the instrument used could register it. Irregularities developed in the pulse toward the end of the attack. These were studied with the electrocardiograph and showed short runs of both auricular and ventricular tachycardia.

She remained in the hospital eight days under observation and in addition to the examinations described above, a number of fruitless studies were made which added nothing to our knowledge of the nature of the attacks.

Because of the foregoing history and examinations, a diagnosis of tumor of the suprarenal was made by Doctor Pincoffs. The thing that immediately concerned us was to determine which gland was involved. We had found two patients with similar symptoms in the literature and in both, the tumor was on the left side. The most careful palpation and percussion gave us no help and X-ray examination showed nothing unusual on either side. It would be difficult to remove either suprarenal through one incision, unless a mid-line incision were used and a transverse cut through the rectus muscle and lateral abdominal wall were made toward the side of the tumor. We were

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afraid of a prolonged operation, because of the great hypertension during attacks and the rapid fall in blood pressure at the end of the attacks. We decided to guess as to the side of the tumor and if we guessed wrong to close that incision and to operate later through another approach.

Accordingly, June 14, 1928, a high left rectus incision was made and the left kidney and post-peritoneal region carefully explored. The left suprarenal was normal in size, consistency and shape and no evidence of any post-peritoneal tumor on the left side was found. There was a little accessory spleen in the peritoneal folds just lateral to the spleen. This was definitely splenic tissue and was about the size of a marble. The right side of the abdomen was then explored by palpation and a large, somewhat kidney-shaped tumor mass was felt just above the right kidney, between it and the liver, on a plane a little anterior to the kidney and mesial to it. It had some range of motion, was behind the peritoneum and was not attached firmly to either kidney or liver. It had about the consistency and movability of an enlarged thyroid in Graves's disease. It could not be reached through the left rectus incision and so it was decided to close the abdomen and wait until healing had taken place and then to approach the tumor through a different incision. The patient made a good operative recovery, although she continued to have almost daily attacks of paroxysmal hypertension. In one of these attacks she developed considerable dyspnoea, cyanosis and a very high blood pressure and it seemed, for a time, that she had developed a pulmonary infarct. These symptoms rapidly cleared up, however; no physical signs in the chest persisted and there was no spitting of blood.

Thirteen days later on, the patient was operated on the second time. She was placed on the operating table

with her body tilted, so that the anterior axillary line on the right side was uppermost. A short incision was made parallel to the costal margin, extending from the outer border of the sheath of the right rectus muscle to the end of the eleventh rib. (Fig. 1.) The peritoneum was opened through this incision and the tumor palpated. It was found that it could be reached best by lengthening the incision intercostally between the tenth and eleventh ribs. This was done. This exposed the lower margin of the right lobe of the liver. Some difficulty was had in retracting the edges of the wound. Accordingly, both the tenth and eleventh ribs were cut across by an osteotome and this allowed a wide separation of the ribs. The hand of an assistant was used to retract the liver upward and this brought into view the ascending colon and its hepatic flexure, the right kidney and the tumor mass. (Fig. 2.) The parietal peritoneum lateral to the ascending colon was incised for a considerable distance and the colon mobilized and packed off to the left. This pre-



FIG. 1.—Incision to expose the suprarenal body.

vented the small intestines from pushing into the operative field and brought the tumor directly into view. It was smooth, almost as large as the patient's kidney and lay immediately above the kidney and in contact with it below and tucked up very close to the under surface of the liver; above laterally it lay against the posterior abdominal wall and mesially it was in close contact with the ascending vena cava for several inches. It was quite firm in consistency, although not of stony hardness, smooth and was surrounded by a somewhat loose outer covering of areolar tissue containing a considerable number of large vessels. Between the mass and the kidney there was a strip of fatty tissue containing vessels that were quite large. The outer covering of the tumor mass was incised and this gave a very good exposure of it. There were a number of large vessels running from

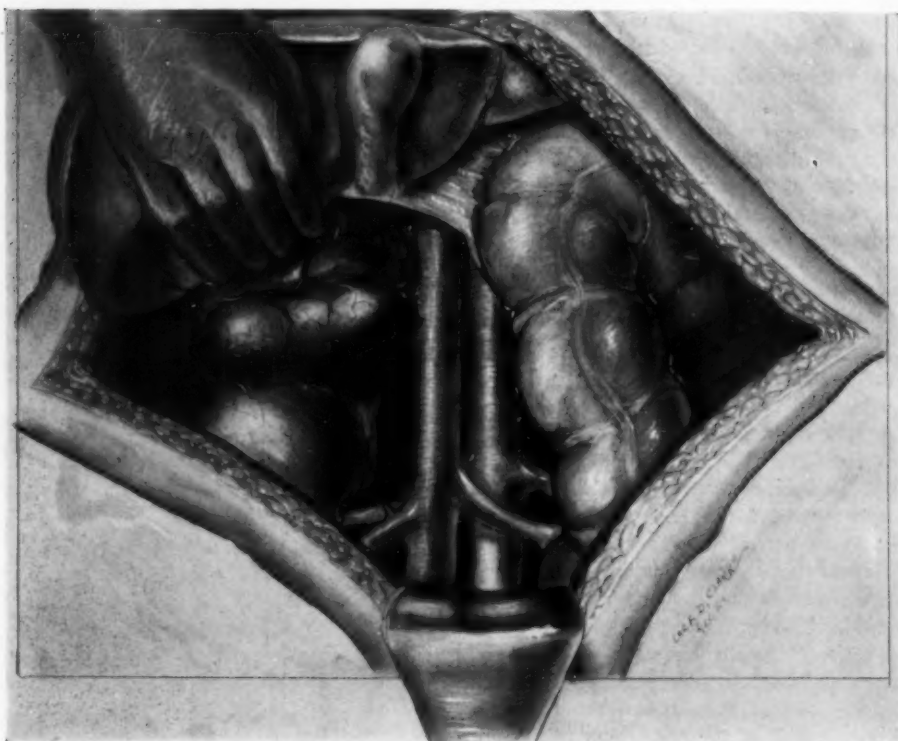


FIG. 2.—The tumor exposed.

this outer layer of loose connective tissue to a dense, smooth capsule intimately adherent to the tumor. The tumor, however, could be separated from its bed and a number of clamps were applied wherever veins were visible. No definite pedicle could be made out. The blood supply was abundant and came into it from a number of directions. The tumor was separated from the surrounding structures and considerable hæmorrhage was encountered in two localities; one below the tumor and between it and the kidney. This hæmorrhage was not difficult to control. The chief return blood supply went from the tumor mass directly into the ascending vena cava at about the level of the middle of the tumor and considerable difficulty was encountered in finding room enough between the tumor and the vena cava to apply clamps. After the tumor (Fig. 3) was removed there was some bleeding in this area and a good deal of anxiety was felt in controlling it, as it was feared that the vena cava would be torn. Altogether, the patient lost about eight ounces of blood. The clamps were tied and two cigarette drains were left in position. The duodenum was not seen; it was kept in mind because of its position behind the peri-



## TUMOR OF THE SUPRARENAL

toneum and its relationship to the upper pole of the right kidney and to the right suprarenal. The patient's blood pressure varied sharply during the operation and she was infused on the table with normal salt solution. The wound was closed and she left the table quite shocked.

During the operation a careful record of blood pressure was kept by Doctor Pincoffs. She had no attacks of hypertension just previous to operation nor did any occur during or after operation. Her highest systolic pressure on the operating table was 152, and three other readings of 140, 130 and 138 were made in the early stages of the operation. As the operation progressed the blood pressure steadily dropped until just after the tumor was removed, when it was 88/62. After this the systolic varied between 94 and 110, and just as she left the table was 75. The anæsthetization, preparation, operation and dressing occupied one hour and twenty-five minutes. The patient left the table badly shocked and the blood pressure remained very low for several hours after operation. Her condition during this time was critical; well-marked grayish cyanosis, respirations rapid and shallow. She was given a transfusion of about 400 cubic centimetres and stimulated with an ampoule of caffeine sodium benzoate. At the most critical period she spat up a small quantity of frothy sputum containing some bright red blood. She then began to improve and later in the afternoon her condition had improved markedly. By the following morning her condition was good. Throughout convalescence, her blood pressure remained low. The day following operation it was 116/74, the next day 118/64 and from that time until July 10, it ranged between 95/65 and 110/70. She stood this low blood pressure very well and had no attacks of hypertension during her stay in the hospital after operation, and reports herself, ten months later, as entirely well and free from attacks.

The only post-operative complication was a rise in temperature and moderate pain in one leg, twelve days after operation. There was very little swelling or tenderness. It was diagnosed thrombo-phlebitis and treated accordingly. In a few days, these symptoms had disappeared.

The pathologist's report, made by Dr. Hugh R. Spencer, is as follows:

*Gross.*—The tumor weighs 115 grams, size  $9 \times 7 \times 3.5$  centimetres. It is completely encapsulated. On one side there is an orange-yellow row of tissue, which resembles adrenal cortex. It is soft. The cut-surface is gray in places while in other places it is red and appears hæmorrhagic. Some very small spaces (cysts?) are seen deep in the gross. The yellow tissue mentioned above, on section appears to be adrenal cortex with a very small gray portion, which resembles medulla and which appears to be continuous with the main portion of the tumor. All the yellow tissue is not more than one centimetre wide and two millimetres thick and extends as a narrow strip along one side for almost the entire length. At one place a small orange-yellow mass is found deep in the tumor. This mass is only two to three millimetres in diameter and resembles cortex.

*Gross Diagnosis.*—Tumor of Medulla of Adrenal.



FIG. 3.—The tumor after removal.



## DISCUSSION

*Microscopic.*—Frozen section as stained with scarlet-red (Herxheimer) shows no fatty material in tumor cells. Fatty material is found in abundance in cells of cortex. Tumor tissue fixed in a solution of chrome salts assumes a yellowish color. Sections show a tumor composed of oval and polygonal cells arranged in alveoli separated by capillaries. The nuclei are of various shapes, some are hyperchromatic.

*Microscopic Diagnosis.*—"Paraganglioma."

## REFERENCES

- <sup>1</sup> Berdez : Contribution a l'étude des tumeurs des capsules surrénales. Arch. d. méd. exper. et d'anat. path., vol. iv, p. 414, 1892.
- <sup>2</sup> Neusser : Nothnagel's Spezielle Pathologie und Therapie, Vienna, vol. xviii, p. 71, 1898.
- <sup>3</sup> Vaquez : Tr. Cong. franç. de méd., p. 338, 1904.
- <sup>4</sup> Oppenheimer, B. S., and Fishberg, Arthur M.: The Association of Hypertension with Suprarenal Tumors. Arch. Int. Med., vol. xxxiv, p. 631, 1924.
- <sup>5</sup> Rabin, Coleman B.: Chromaffin Cell Tumor of the Suprarenal Medulla (Pheochromocytoma), Arch. of Path., vol. vii, p. 228, Feb., 1929.
- <sup>6</sup> L'abbé, Tinel and Doumer: Crises solaires et hypertension paroxystique en rapport avec une tumeur surrénale. Bull. et mém. Soc. méd. d. hôp. de Paris, vol. xlvi, p. 982, 1922.
- <sup>7</sup> Oberling, C., and Jung: Paraganglioma de la surrénali avec hypertension. Bull. et mém. Soc. méd. d. hôp. de Paris, vol. x, p. 366, 1927.
- <sup>8</sup> Mayo, Charles H.: Paroxysmal Hypertension with Tumor of Retroperitoneal Nerve: Report of a Case. Collected Papers of the Mayo Clinic and the Mayo Foundation, vol. xix, p. 732, 1927.
- <sup>9</sup> Vaquez, H., and Donzelot, E.: Les crises d'hypertension artérielle paroxystique. Presse méd., vol. xxxiv, pp. 1329-1331, 1926.
- <sup>10</sup> Laubry, M. Ch.: Hypertension Paroxystique Guérie par la Radiothérapie de la Région Surrénale. Bull. et Mém Soc., méd. d. hôp. de Paris, vol. xxi, pp. 1216-1221, 1927.
- <sup>11</sup> Donzelot, E.: Les modalités cliniques de l'hypertension artérielle paroxystique. (The Clinical Modalities of Paroxysmal Arterial Hypertension.) Paris méd., vol. lxix, pp. 19-21, July 7, 1928.

DISCUSSION: DR. GEORGE W. CRILE of Cleveland, Ohio, remarked that he had removed the adrenal gland in twelve cases of hypertension. These cases had been followed, some for as long as twelve or ten years.

On the operating table there would be a fall in the blood pressure. This fall would sometimes persist for a few days, or a few weeks and then after that period the blood pressure would run an irregular course. As a whole, he was unconvinced that he produced any results. This report has no bearing on the case that was reported by Doctor Shipley; it is offered only to record a warning that we cannot put too much faith—as Doctor Shipley does not infer—in the fact that this tumor had a certain effect on the blood pressure.

DR. ROBERT TALBOT MILLER, JR., of Baltimore, Md., reported a case which possibly has some analogy to the condition described by Doctor Shipley; although the analogy is not quite clear.

It concerned a man of sixty, a very active and intelligent man who had been in the best of health. For a period of a year and a half to two years he had been suffering with attacks of precordial pain and distress and anxiety and was a picture of possible angina pectoris. He was submitted to very careful study and put into the hands of a very skillful internist. The study

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was made with the utmost detail. The internist concluded he was suffering from functional angina pectoris. He observed that with each attack the man had an extremely rapid and quite a marked rise in blood pressure, which persisted throughout the attack. He confirmed the previous findings, but was unable to find any reason for these attacks. He found, however, in the right lobe of the thyroid an adenoma, perhaps three cubic centimetres in diameter. The man was utterly miserable and the situation was explained to him. The internist suggested that the adenoma be removed with the hope that it would relieve his condition and he consented.

Doctor Miller took out a normal right lobe of thyroid containing the adenoma. The man was convalescent and out of bed in a little while and since that time has not had an attack. He has apparently recovered completely and is leading an active life.

## END RESULTS IN THYROCARDIACS

BY FRANK H. LAHEY, M.D.

OF BOSTON, MASS.

THE surgical management of patients with thyroid disease has shown within the last decade a striking—if not the most striking—development that has occurred in the surgical management of any disease. As an indication of the truth of this statement we have but to call attention to the great value of the use of iodine, for the practical application of which we are so much indebted to Dr. Henry S. Plummer; the elimination for the most part of preliminary pole ligations; the better management and the prevention of non-surgical thyroid crises; the avoidance of severe post-operative reactions; the immediate search for and transplantation of removed parathyroid bodies, as proposed and practiced in our clinic to lessen the possibility of post-operative tetany; the critical elimination of patients with non-thyroid neurotic states as candidates for subtotal thyroidectomy; the lessening of the likelihood of carcinoma of the thyroid by the prophylactic removal of fetal adenomata, the propensity of which to show carcinomatous changes particularly characterized by vessel ingrowth has been so well demonstrated by Dr. Allen Graham; the reduction of the operative mortality rates in all organized thyroid clinics to almost trivial figures. In our clinic, during the year 1927, the total operative mortality rate was 0.6 per cent. in 954 patients; in the year 1928, the total operative mortality rate was 0.27 per cent. in 1068 patients; the mortality rate in exophthalmic goitre 0.15 per cent. in 618 patients. In addition, we have the almost universal acceptance of surgery as the method of treatment of toxic goitre; and, finally, the feasibility, as we have proven in our experience, of subtotal thyroidectomy in patients with even seemingly hopeless degrees of cardiac failure due to thyroidism, and the almost miraculous restoration of cardiac capacity which may be obtained by this procedure. We have been particularly interested in this latter group of cases which I have myself, in writing on this subject, grouped under the term "thyrocardiacs." This term is, from a puristic point of view, quite improper, but nevertheless serves a most excellent purpose in calling attention to this hitherto often overlooked condition as an entity, and particularly as an entity not hopeless but, in large part, relievable.

We were led into this field of what we have called "thyrocardiacs" by feeling the restrictions of further development in the usual field of thyroid surgery, as the result of the advances which have already been enumerated.

Claims of priority usually lead but to conflict, bitterness, and a final realization that in this day and generation there is little that is novel, and even less that is truly new. Therefore, we wish to assert that we have no desire to claim priority in relation to thyrocardiacs, but are particularly prompted by a desire to promote an interest in, and a conception of, this

## END RESULTS IN THYROCARDIACS

state which will result in the acquiring of wider ability to recognize it, and a realization that this apparently hopeless condition is capable of being improved to a remarkable degree by subtotal thyroidectomy.

As the result of our experience with thyroid disease, we have come to the conclusion that thyroidism in itself does not cause heart disease, and that there is no heart state which can be designated as a true thyroid heart. These conclusions we have had demonstrated to us again and again in observing young people with thyroidism of such a degree that the pulse rates became uncountable. We have observed such young individuals with intense, and eventually fatal, degrees of thyroidism over considerable periods of time, yet at no time—even up to death—has there been present in these young persons any cardiac decompensation. They have not shown orthopnoea; they have been able to lie flat in bed without respiratory embarrassment; they have had no œdema; and they have shown no enlargement of the liver. Furthermore, there has never been presented in the laboratory nor in the literature any convincing evidence that thyroidism in itself ever produced any selectively destructive effect upon the heart.

We believe that the cardiac states, auricular fibrillation and cardiac decompensation, so often associated with thyroidism, are, therefore, not due to a destructive effect of thyroidism upon the heart, which is unable to withstand the excessive burden of the superimposed drive of hyperthyroidism. Auricular fibrillation and heart failure result, and the individual then falls into the group which we have called "thyrocardiacs."

The observation that auricular fibrillation and cardiac decompensation, associated with thyroidism, occur most commonly in patients of middle age and, particularly, later life, and very rarely in young individuals, further suggests that the explanation of cardiac failure associated with thyroidism is the preëxistence of a damaged or of a handicapped heart.

It is important to establish this conception of the cause of cardiac failure associated with thyroidism, since it permits of a reasonable explanation of why failure occurs; why patients, in what appear to be hopeless states of cardiac decompensation, successfully endure general anæsthesia (ethylene) and a major surgical operation. It explains why, by subtotal thyroidectomy, which removes the superimposed cardiac burden (thyroidism with its excessive drive), it is so possible to restore cardiac compensation; and why, by elimination of this extra cardiac burden, seemingly hopeless individuals regain surprising degrees of cardiac capacity and an ability for general activity.

The diagnosis of thyroidism associated with and resulting in heart failure is not the simple accomplishment it may seem, particularly since the more severe and urgent the symptoms of cardiac failure, the more obscured and overshadowed are the symptoms of thyroidism.

One of the reasons why it is often difficult to recognize thyroidism associated with heart failure is because of the fact that the symptoms of thyroidism in these elderly patients are usually not those of activation, as so typically

occurs in young persons, but rather the apathy which so frequently appears with thyroidism occurring in older individuals.

With opportunity to observe several thousand cases of thyroidism and their response to conditions of stress, we have had it impressed upon us that there are two opposing types of reaction to thyroidism: First, that of activation, which so commonly occurs in young people, with the classical picture of the disease, doubtless the response of the vigorous, energetic, alert organism of youth and early adult life to the intoxication; and secondly, apathy—the more sluggish, quiescent, indolent response to the intoxication—which occurs in individuals occasionally in late middle life, but more often in later years with less vigorous and less responsive organisms, also due possibly (although it is unlikely) to a different kind of thyroid intoxication.

We have particularly called attention to this apathetic type of thyroidism in connection with cardiac decompensation, with which it is so commonly associated, and I would state from our contact with this type of reaction, for the benefit of those who have not been impressed by, nor appreciated, the existence of this condition, that in any form of thyroidism, exclusive of its association with cardiac decompensation, it is the more dangerous of the two states of thyroid reaction. It occurs in individuals with less capable organisms, and, since it is less striking and less direful in appearance, it tends to lead one who has activation in mind, as an index of toxicity, into a false sense of complacency, or a complete oversight of the presence of such a potentially serious thyroid situation. A failure to appreciate the unobtrusive dangers of this apathy of varying degree in thyroidism has not infrequently in the past been—and even still threatens to be—the explanation of at least a part of an ever-present, even though trivial, mortality in the surgery of thyroidism.

We have now operated upon 138 patients who would fall into the group which we have designated as thyrocardiacs; and of this group five died while still in the hospital, an operative mortality rate of 3.6 per cent.

The causes of death in these five patients who succumbed while still in the hospital were as follows: One patient died of post-operative mediastinitis following the removal of a toxic retrotracheal goitre in the presence of severe decompensation; one, forty-five years of age, died of status lymphaticus, as proven by autopsy; one died of probable pulmonary embolism; and two died sudden deaths of unknown origin, no autopsy being permitted.

There were four cases in which operation was not done,—one dying of bronchopneumonia before operation; one toxic patient with hopeless malignancy; one dying of tracheal obstruction before operation; and one patient who refused operation.

Of the operated cases, twelve cases have died since operation, after leaving the hospital.

Four died with congestive heart failure,  
Three died sudden deaths,  
One died of pneumonia,  
Four died of undetermined causes.



## END RESULTS IN THYROCARDIACS

It is presumed, then, that of the entire group here considered,

One hundred and one are living,  
Eighteen are untraced,  
Five died operative deaths (while still in the hospital),  
Twelve have died since operation (see types of death above),  
Two died of causes other than heart, after leaving hospital,  
Four were not operated upon,

making a total of 142 cases considered in this end result study.

It has frequently been suggested that cardiac complications were more apt to occur in patients with toxic adenomata or secondary hyperthyroidism than in those with exophthalmic goitre or primary hyperthyroidism. As evidence that these suggestions are not true, of the pathological reports on the tissue removed (except in the four cases in which operation was not done, in which a clinical diagnosis was employed) forty-nine were adenomatous goitres, or secondary hyperthyroidism, and ninety-three were exophthalmic goitres, or primary hyperthyroidism. I do not believe that there is any difference in the toxicity associated with adenomatous goitre and that associated with exophthalmic goitre and its relation to cardiac complications. As is the case in this study, I believe that the type of toxic goitre which predominates in the community in which the surgery is done will predominate in the figures of that study.

It is of interest to observe that the average duration of cardiac symptoms before operation, as given by the histories in this study, was two and one-half years, and that the average number of years during which the ninety-five patients have been well and active after operation is three and one-half years.

The post-operative end result in cardiac function in the 101 traced thyrocardiacs is as follows:

|   |    |
|---|----|
| Full return to former activity .....    | 95 |
| Persistent auricular fibrillation ..... | 19 |
| Partially disabled .....                | 4  |
| Completely disabled .....               | 2  |

Of the 138 operated cases, forty-six were done in two stages; two have been operated upon for recurrent hyperthyroidism; and three are known still to have persistent hyperthyroidism.

Fifty-five patients had mild failure, fourteen moderate failure, and forty-two severe failure. Under mild failure were grouped those patients having œdema and marked dyspnœa on attempted activity. Under moderate, those patients having œdema, enlarged liver, orthopnœa, requiring rest in bed and active treatment. Under severe, those patients with anasarca, hydrothorax, large liver, orthopnœa and dyspnœa at rest, and requiring intensive medical treatment.

The incidence of auricular fibrillation (established, not transient) in the 142 cases before operation was as follows:

# FRANK H. LAHEY

|  |                          |
|--|--------------------------|
| Established auricular fibrillation ..... | 122 cases 85.9 per cent. |
| Paroxysmal tachycardia .....             | 2 cases 1.4 per cent.    |
| Normal rhythm .....                      | 18 cases 12.6 per cent.  |

Of the 142 patients in this study, there was present

|  |          |
|--|----------|
| Auricular fibrillation with clear-cut congestive failure in.....   | 92 cases |
| Auricular fibrillation without clear cut congestive failure in.... | 30 cases |
| Normal rhythm with congestive failure in .....                     | 18 cases |
| Paroxysmal tachycardia with congestive failure in .....            | 1 case   |
| Paroxysmal tachycardia without congestive failure in .....         | 1 case   |

142

The age distribution of the group is as follows, demonstrating, as we have often stated, the inclination of the thyrocardiac state to occur in later life, and in hearts which are handicapped or crippled:

| Age   | Number |
|-------|--------|
| 20—29 | 1      |
| 30—39 | 17     |
| 40—49 | 37     |
| 50—59 | 56     |
| 60—69 | 27     |
| 70—75 | 4      |
|       | —      |
|       | 142    |

## SUMMARY

Attention is directed to apathy in contradistinction to typical activation as a frequent indication of thyroidism in thyrocardiacs and thyroidism of later life.

The mortality (total hospital) of 138 operated thyrocardiacs, ninety-three of whom were in varying degrees of congestive failure, was 3.6 per cent. (Five deaths.)

The average history of symptoms (heart) before operation was two and one-half years; the average period during which patients have been well and active after operation had been three and one-half years.

The fact that, with the exception of the four cases mentioned in the text (two dying in the hospital before operation, one rejected because of an inoperable malignancy, and one refusing operation herself), every thyrocardiac coming to the clinic was operated upon, and practically every one with a general anæsthetic (ethylene), indicates that there are essentially no thyrocardiacs who are too decompensated to withstand subtotal thyroidectomy without an undue risk.

Of the 101 patients traced, and living, an average of three and one-half years after operation, but two are completely disabled, four partially disabled, ninety-five have been returned to the full function which they possessed before the onset of hyperthyroidism.

## END RESULTS IN THYROCARDIACS

DISCUSSION: DR. GEORGE W. CRILE of Cleveland, Ohio, presented figures from Doctor Anderson of his Cardiologial Department. They found in their series that no relation has been established between extra systoles and the thyroid gland before or after operation; paroxysmal tachycardia bears little or no relation to goitre; in essential hypertension there is little or no relation; in the case of auricular flutter a definite relation to goitre is quite rare.

Auricular fibrillation is the most frequent cardiac disturbance. He did not know if one could include that in the thyrocardiac group. Of 150 cases, all of which had an electrocardiographic record made before and after operation, 65 per cent. were restored to normal rhythm and 35 per cent. showed no effect.

Of the 150 cases there were six deaths, or 4 per cent. Doctor Lahey reports 3.6 per cent.

Finally, a mitral systolic murmur is a frequent accompaniment of hyperthyroidism and usually disappears after the operation.

## CHRONIC FIBROUS OSTEOMYELITIS

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CHRONIC fibrous osteomyelitis is a term that may be applied to any long-standing pyogenic infection of the bone in which the reaction on the part of the fibroblasts in contrast with the infiltrative cells becomes the outstanding feature of the lesion. As is well known, it may come as the end stage

of acute pyogenic osteomyelitis in which there has been suppuration, necrosis, absorption, and cavity formation. As repair takes place the cavity may be filled with fibroblastic tissue showing varying degrees of maturation. Brodie's abscess not infrequently becomes quiescent or heals in this way. Such an area of chronic fibrous osteomyelitis may remain symptomless for an indefinite period or it may produce mild disturbances or be the seat of acute exacerbations.



FIG. 1.—Chronic fibrous osteomyelitis of acromion process.

There is usually more or less osteosclerosis with the formation of a bony shell about it. Gradual replacement by hæmopoietic and fatty marrow may ultimately come about.

In contrast with this condition we may see a form of osteomyelitis pursuing a chronic course from the onset in which a circumscribed area of bone is broken down by fibroblastic activity and the space filled up with soft tissue. This lesion deserves special consideration since by the time that it has come to operation it is devoid of the usual microscopic changes of pyogenic infection and bears much resemblance to benign giant-cell tumor and osteitis fibrosa cystica with which it is sometimes confused. I have studied eleven cases belonging to this group particularly from the pathological standpoint. The findings vary greatly according to the age of the lesion. In those cases operated on during the first few months, while the disease is progressive, the

## CHRONIC FIBROUS OSTEOMYELITIS

cavity has been found to be filled with a soft tissue that is grayish to brown in color. Microscopically it consists of fibroblasts, capillaries, polyblasts, giant cells, old hæmorrhage, and blood pigment. There is usually more or less necrosis throughout the tissue. Cholesterol slits are sometimes seen. There is lacunar absorption about the walls of the cavity and the adjacent haversian canals are dilated as a result of absorption by newly-formed fibrous tissue. There is practically no leucocytic or lymphocytic infiltration to be seen. The response on the part of the

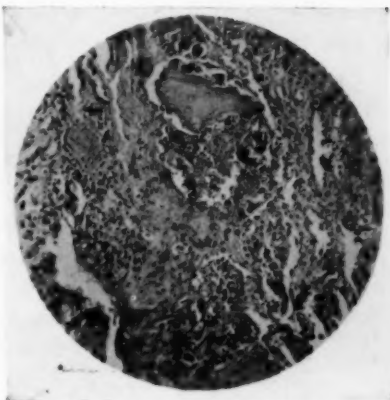


FIG. 2.—Tissue removed from lesion shown in Fig. 1.

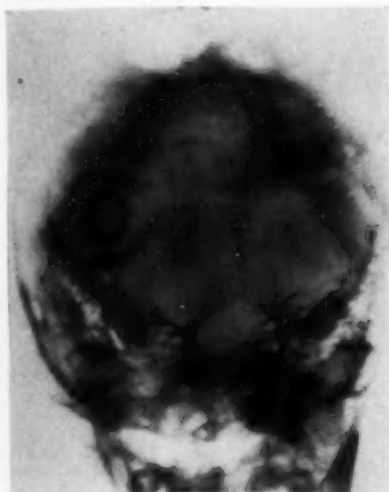


FIG. 3.—Destructive lesion (A) of parietal bone.

surrounding bone is extremely variable. In some instances little or no bone is laid down, while in others, there is marked new bone formation.

The following case is one in which there was bone destruction with practically no surrounding new bone formation: Female, thirty years of age. Six months before admission she began to have pains in the region of the acromion process of the right scapula. They gradually increased in severity and she developed moderate limitation of motion in shoulder. No general symptoms. Examination was essentially negative aside from the region of the right acromio-clavicular joint which was painful on motion and tender on pressure. There was no swelling. A röntgenogram (Fig. 1) revealed destruction of the mesial half of the acromion bordering on the acromio-clavicular joint. No new bone formation. Wassermann negative. At operation the acromion process for approximately one centimetre about the acromio-clavicular joint was missing and the space was filled with soft granulation tissue which bled freely. It was curetted away and the adjacent bone was removed with rongeur forceps. The wound healed *per primum* and six months later the disease appeared to be healed on physical and X-ray examinations. Microscopic examination showed the excised tissue to be composed very largely of fibroblasts with many capillaries, a few giant cells, and monocytes. (Fig. 2.) There were areas of

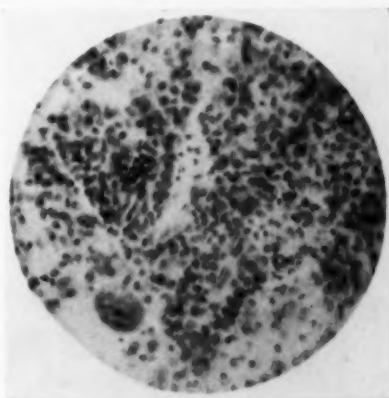


FIG. 4.—Photomicrograph of tissue removed from lesion shown in Fig. 3.



necrosis and occasional polymorphonuclear leucocytes. There were a few small trabeculae of bone undergoing lacunar absorption.



FIG. 5.—Showing a cavity in posterior part of ilium with thin, sclerosed walls.

inch in diameter without accompanying new bone formation. A grayish-brown tissue was curetted from the cavity by Dr. J. C. Clarke and the lesion healed promptly and has remained so for two years. Microscopic examination showed it to be made up mainly of young fibroblasts. Throughout were scattered numerous mono- and multinuclear giant cells and blood pigment. (Fig. 4.) There were very few lymphocytes and polymorphonuclear leucocytes. This is the earliest lesion of the group. No bacteriological examination was made.

In other cases a shell of bone is gradually laid down about the cavity which becomes stationary in size, although the disease may remain active and continue to produce symptoms. The following case is an example of this type. Female, nineteen years of age, gave a history of pain in the left posterior iliac region of nine months' duration. It came on while there was an open wound of the right shin and had varied

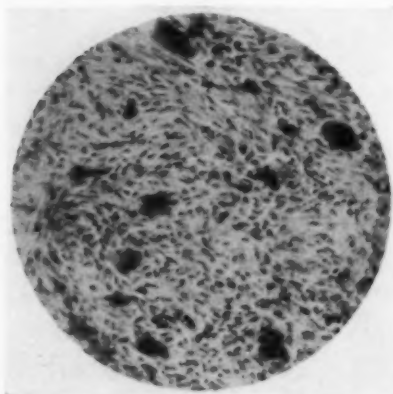


FIG. 7.—High power of tissue shown in Fig. 6.

Cultures of the material on aerobic blood agar showed no growth. Those on meat broth and milk showed staphylococcus aureus. The fact that the histological picture was that of a fibroblastic reaction and that infiltrative cells were present in such small numbers raises the question of whether or not the staphylococcus found in the cultures was a contamination. Guinea-pig inoculations were negative for tuberculosis.

A similar lesion in a girl, twelve years of age (Bone Sarcoma Registry No. 854), was studied pathologically. She had had slight pain and a swelling in the occipital region for two months. A röntgenogram (Fig. 3) revealed a punched out area of bone destruction about one

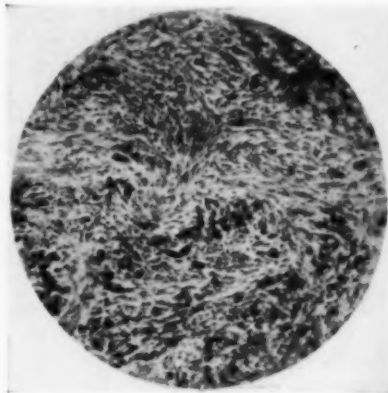


FIG. 6.—Photomicrograph of brown tissue from cavity shown in Fig. 5. It consists of fibroblasts, immature connective tissue, giant cells and blood pigment.

in intensity at intervals. No general symptoms. She had been treated elsewhere for sacro-iliac strain. Examination was negative aside from slight tenderness over the upper part of the ilium bordering on the left sacro-iliac joint. A röntgenogram (Fig. 5) revealed an area of reduced density in the ilium near the sacro-iliac joint with a sclerosed cortex about it. At operation the cavity was found to be filled by fibrous tissue which was grayish in some regions and a mottled brown in others, giving it the gross appearance of the "brown tumor" of the Germans. There was a shell of cortical bone about it. Microscopic examination of the brownish tissue (Figs. 6 and 7) showed that it was made up largely of fibroblasts. There were many large and small giant cells and a large amount of old blood and blood pigment. Few infiltrative cells

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were present. The grayish areas were composed of wavy connective tissue in varying stages of organization. (Fig. 8.) No bacteriological examination was made. The lesion healed and the patient was well four years after operation.

When the lesion is situated along the course of the shaft of a long bone whether centrally or peripherally, there may be very extensive new bone formed about the cavity. The cavity may continue to enlarge slowly and the new bone increase in amount over a considerable period of time. In the following case, the lesion began subperiosteally. Male, fifty years of age, two years before admission began to have dull pain in the mesial side of the upper third of the right tibia. It grew steadily worse and after four



FIG. 9.—Peripheral lesion with central cavity (A) and marked osteosclerosis about it.

months a small tender swelling was noticed. The swelling, pain, and tenderness slowly increased despite the fact that he had four months of antisyphilitic treatment preceding admission. Examination was negative aside from a slightly tender oval swelling extending on the mesial surface of the right tibia five inches below the knee. A röntgenogram (Fig. 9) revealed a dense oval shadow along two inches of the surface of the shaft with a small oval area of reduced density in the cortex, at the centre of the swelling. He furnished X-rays taken ten and seventeen months after the onset showing the gradual increase in amount of periosteal new bone and enlargement of the cavity. Wassermann negative. The entire lesion was excised at operation and the cavity was found to be filled with a grayish-brown soft tissue. Aërobic and anaërobic cultures made on blood agar plates gave no growth. Microscopic examination of the tissue removed from the cavity (Fig. 10) showed it to be made up largely of fibro-

blasts. There were also many small and a few large giant cells and polyblasts. Extremely few leucocytes were seen. There were scattered areas of blood pigment and extravasated red blood cells. Very fine trabeculae of new bone were seen in the peripheral portion of the tissue. The surrounding new and old bone possessed large cancellous spaces which were filled with fibrous marrow and there was evidence of bone absorption along the wall of the cavity.

This lesion was still in the progressive stage and at the time of operation was producing more marked symptoms than at any time previously. Despite these facts there was almost complete absence of leucocytic infiltration such as would be expected in a pyogenic infection. The patient

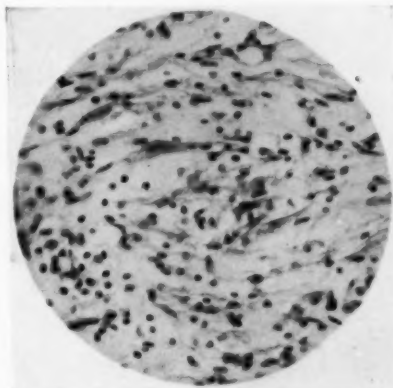


FIG. 8.—Photomicrograph of gray tissue from cavity shown in Fig. 5.

months a small tender swelling was noticed. The swelling, pain, and tenderness slowly increased despite the fact that he had four months of antisyphilitic treatment preceding admission. Examination was negative aside from a slightly tender oval swelling extending on the mesial surface of the right tibia five inches below the knee. A röntgenogram (Fig. 9) revealed a dense oval shadow along two inches of the surface of the shaft with a small oval area of reduced density in the cortex, at the centre of the swelling. He furnished X-rays taken ten and seventeen months after the onset showing the gradual increase in amount of periosteal new bone and enlargement of the cavity. Wassermann negative. The entire lesion was excised at operation and the cavity was found to be filled with a grayish-brown soft tissue. Aërobic and anaërobic cultures made on blood agar plates gave no growth. Microscopic examination of the tissue removed from the cavity (Fig. 10) showed it to be made up largely of fibro-

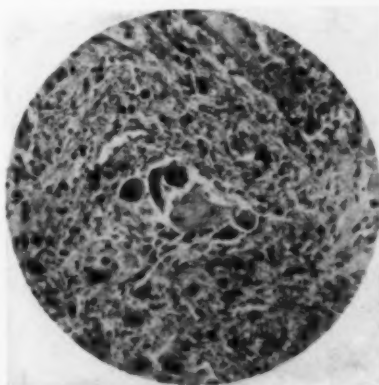


FIG. 10.—Contents of cavity in Fig. 9.



FIG. 11.—Shadow of dense bone about fibrous area, in medullary cavity.

ing wavy fibres and almost free from giant cells and blood pigment. (Fig. 14.) There were no leucocytes. The contents of the cavity appeared to be in a quiescent stage. These two cases might perhaps as well be classed as sclerosing osteomyelitis but the fibrous nature of the reaction at the point of onset of the lesion is the pathological feature of greatest importance.

After a progressive period which may extend over a number of months or years, the disease may come to a standstill or healing take place, in which event a cortex is laid down about the lesion and the cavity becomes filled with a mature connective tissue that is free from giant cells and blood pigment. This connective tissue may remain unossified or there may be fine bony trabeculae laid down throughout it, particularly in the peripheral regions. Some of these lesions produce very few or even no symptoms at the onset and all are apt to become symptomless as the reparative stage is reached. Consequently they may be detected as unexpected findings in roentgenograms made because of trivial complaints.

was completely relieved by the operation and was well one year later.

An example of marked sclerosis in lesion situated in the medullary canal is that of a female, twenty-three years of age, who had pain in the lower end of the shaft of the right tibia for three months without any general disturbance. Examination was negative aside from tenderness along the shaft of the tibia just above the epiphysis. A roentgenogram (Fig. 11) revealed a large, oval, dense shadow extending into the medullary cavity from the lateral cortex of the lower two inches of the diaphysis. In the lateral view (Fig. 12) an area of reduced density is seen at the centre of the shadow. The sclerosed area was excised by Dr. John Hodgen. The specimen consisted of lateral cortex of the tibia and an oval mass of densely trabeculated bone attached to its inner surface. There was a central cavity one by two centimetres in diameter (Fig. 13) which was filled with a grayish soft tissue. On microscopic examination it was found to be loose connective tissue contain-

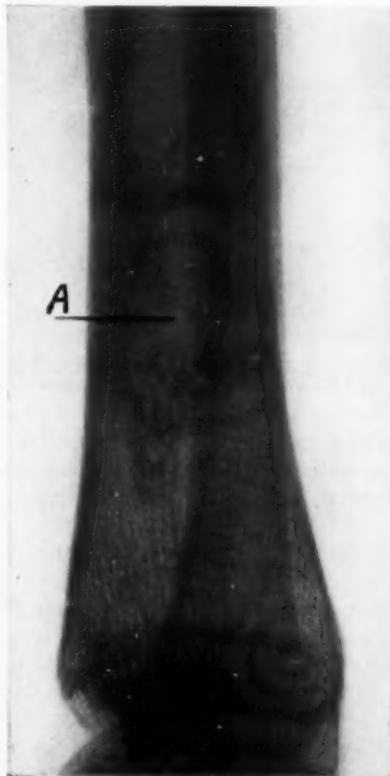


FIG. 12.—Lateral view of lesion in Fig. 11, showing reduced density at seat of cavity in central portion (A).

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FIG. 13.—Excised lesion shown in Figs. 11 and 12 with central cavity (A).

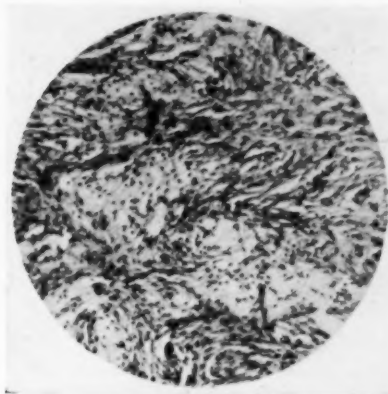


FIG. 14.—Photomicrograph of tissue from cavity shown in Fig. 13.

at intervals, for two months. Physical examination was negative. A röntgenogram (Fig. 15) showed an oval area of reduced density in the lateral portion of the femur three inches above the knee. Pathological examination of the excised lesion revealed a dense bony shell and mature white fibrous connective tissue filling out the cavity. (Fig. 16.) There were no areas of necrosis or hæmorrhage and practically no signs of phagocytic activity indicative of active inflammation. A similar case was that of a thirteen-year-old girl who for one year had had mildly intermittent pains in both knee-joints. There had been no general symptoms. Physical examination revealed slight tenderness on the mesial side of the right knee. The joint appeared otherwise normal. A röntgenogram (Fig. 17) unexpectedly disclosed an oblong area of reduced density (a) in the shaft of the right fibula near its upper end. There was a dense narrow shadow

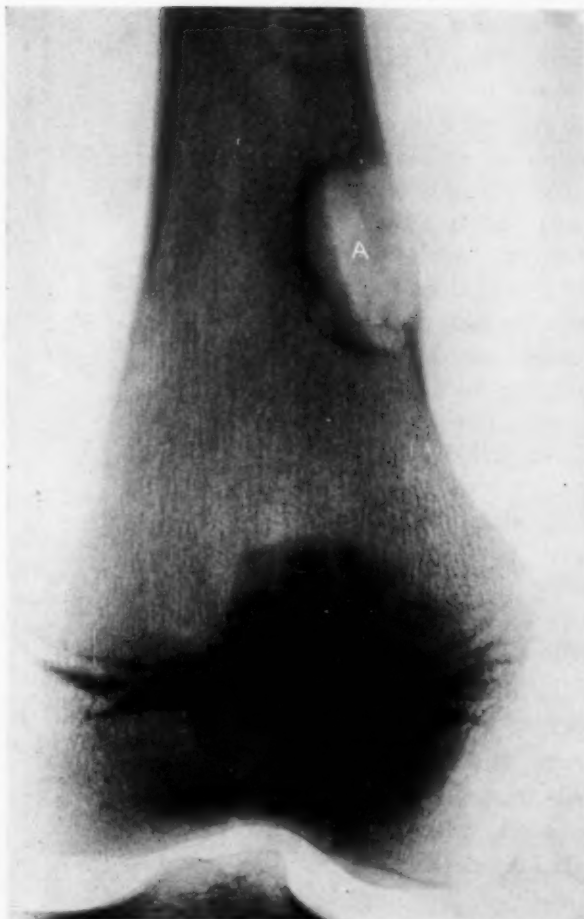


FIG. 15.—Cavity filled with fibrous tissue and surrounded by sclerosed wall.

about it indicative of bony encapsulation. The shaft of the fibula in the involved region was resected subperiosteally. On longitudinal section the segment was found to contain an oblong area filled with grayish-white soft tissue which was surrounded by a dense

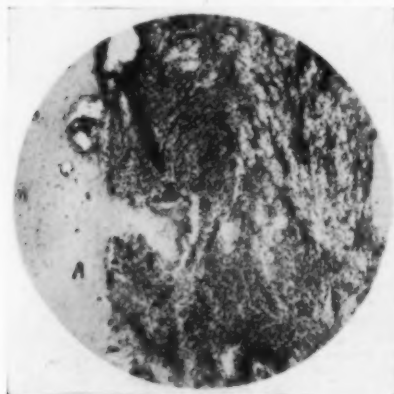


FIG. 16.—Photomicrograph of sclerosed bony wall (A) and of fibrous contents of cavity shown in Fig. 15.

Since we do not know the pathology of the very early stages of these lesions it is impossible to say whether they began as ordinary pyogenic inflammatory processes or whether the changes here observed were continuous throughout the entire progressive period of the lesion. But the fact that those operated on during the active period showed no leucocytic or lymphocytic infiltration favors the latter view. The tissue filling the cavity during the active stage bears some resemblance to that lining the cavity of a bone cyst, and its brown areas containing giant cells resemble giant-cell tumor which Barrie called hæmorrhagic osteomyelitis. The localizing tendency and the sur-

narrow cortex of bone. (Fig. 18). Microscopic examination showed the cavity to be filled with loose white fibrous connective tissue. There was a small amount of blood pigment to be seen but no giant cells or infiltrative cells. Along the bony wall there was an occasional osteoclast producing bone absorption, but in other places newly-formed bony trabeculae were seen in the fibrous tissue. (Fig. 19.) It is impossible to state when this lesion had developed, but it was apparently in a quiescent state and had it been left alone, would probably have produced no disturbance in the future. Cultures of the soft tissue were made on aerobic and anaerobic blood agar plates, Rosenow's media, deep shake agar tubes and plain broth. They remained sterile.

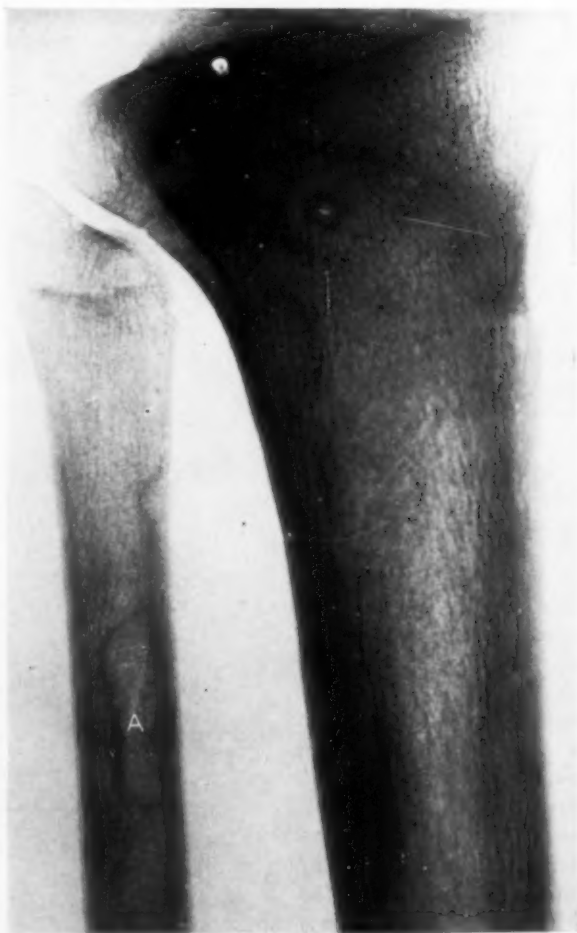


FIG. 17.—Cavity (a) with sclerosed wall in medullary canal of fibula.



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rounding osteosclerosis are much less consistent with bone cyst and giant-cell tumor, than with pyogenic osteomyelitis. Osteitis fibrosa cystica may heal by filling out of the cavity with fibrous tissue and subsequent incomplete ossification very similar to the end stage seen in some of these lesions.

The etiology of the eleven cases that have been observed has been very

imperfectly investigated. There appeared to be nothing in the histories that had any bearing on the cause except the infected open wound on the leg in the case of involvement of the ilium, which may have been the portal of entry of the microorganism. In four cases no bacteriological examination was made. In two



FIG. 18.—Photograph of section of fibula of Fig. 17, showing cavity filled with grayish fibrous tissue and surrounded by a bony cortex.

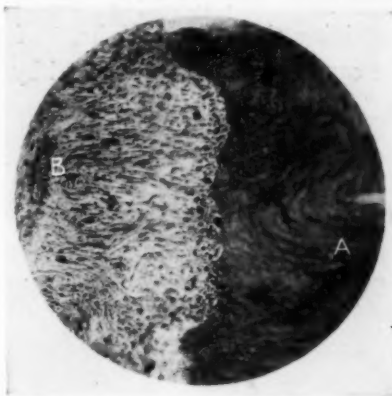


FIG. 19.—Photomicrograph of bony wall (a) and of fibrous contents of cavity (b) shown in Fig. 1.

cases staphylococcus aureus grew in the cultures. In the remaining five cases the cultures remained sterile, but in only two were both aerobic and anaerobic cultures made that might have permitted the growth of any form of pyogenic organism. Konjetzny (*Archiv für Klinische Chirurgie*, vol. cxxi, p. 567, 1922) and Losser (*Deutsche Zeitschr. f. Chir.*, vol. clxxxv, p. 113, 1924) regard so-called brown tumors as the result of hæmorrhage that sets up an active absorptive process within the bone. However, the absence of a history of traumatism and the nature and duration of the changes are entirely inconsistent with an explanation on a purely traumatic basis. Axhausen (*Archiv. f. Klin. Chir.*, vol. cli, p. 72, 1928) has described anæmic infarcts of bone. He believes that in the process of organization of such areas there may be connective tissue invasion of the necrotic field with absorption, hæmorrhage, and cyst formation or fibrous tissue replacement with the establishment of connective tissue islands similar to those observed in some of the cases here described. It is possible that embolism and infarction play a rôle in the production of some of the lesions in this group as the last three described, but bacterial infection must also be present as the clinical manifestations in some cases and pathological changes could not be accounted for on the basis of aseptic necrosis alone.

The most probable explanation of these lesions appears to be that they are produced by organisms of low virulence belonging to the pyogenic group but not setting up the usual cytological reaction of pyogenic inflammation. This is rendered more plausible by the fact that streptococcus viridans has

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grown in cultures of bone cysts and osteitis deformans and it has been cultivated from inflammatory changes in rheumatism, such as the Aschoff bodies of the heart and the nodules in the skin in which fibroblasts, giant cells, and polyblasts may predominate over leucocytic cells. They constitute a borderline group of lesions which require further investigation from an etiological standpoint but their pathological and clinical characteristics warrant us in retaining them as a sub-head of chronic osteomyelitis. Some of them may be organized infarcts infected by microorganisms of low virulence.

## RETROCÆCAL INTERNAL HERNIA

BY WILLIAM B. COLEY, M.D.

AND

JOSEPH P. HOGUET, M.D. (By Invitation)  
OF NEW YORK, N. Y.

RETROPERITONEAL hernia is a very rare condition; only a small number of cases have been reported in the literature. Lord Moynihan<sup>1</sup> in his Arris and Gale lecture on "The Anatomy and Surgery of the Peritoneal Fossæ" gives us the most lucid and detailed description of this condition. The most common form of retroperitoneal hernia occurs in the duodenal fossæ. These fossæ were mentioned by Hensing<sup>2</sup> in 1742 and also by Waldeyer<sup>3</sup> (1868), who made a very careful study of the anatomy of the peritoneal fossæ and published an excellent description thereof.

As to the origin of these fossæ, Treitz<sup>4</sup> attributes their existence to the embryonic movement of the intestinal canal. Waldeyer suggests a vascular theory, based upon the idea of the close relationship of the fold and the inferior mesenteric vein. According to Treves,<sup>5</sup> the inferior duodenal fold represents the remains of the mesoduodenum. He states: "More peritoneum is required by the cæcum and ascending colon, and it is obtained from that of the posterior parietes, and in great measure by the unfolding of the mesoduodenum." Moynihan holds that these folds are to be regarded as *fusion folds* between the original left, afterward anterior, surface of the ascending portion of the duodenum and the right or anterior surface of the descending mesocolon folds, which date their origin from the time when these two peritoneal surfaces are in close apposition. Such a time is at the end of the third or the beginning of the fourth month. According to Toldt<sup>7</sup> it is only in the eighth month of intra-uterine life that the folds are formed; although, in one of his figures he shows the folds quite distinctly developed in the fifth month.

In his publication of 1897 Moynihan had collected fifty-seven cases of left duodenal hernia, to which, in his second edition of 1906, he added sixty-three cases more.

The ileocolic or ileocæcal hernia is much more rare. Santorini<sup>8</sup> in 1775 first described the fossa in this region. According to Moynihan no further mention was made of it until 1834 when Huschke<sup>9</sup> described two fossæ bounded by three folds, made evident by traction on the vermiform appendix. In 1857 Treitz<sup>10</sup> described a third or "subcæcal" fossa. In regard to this Moynihan quotes Treitz, as follows: "Sometimes there is but a trivial excavation, at other times there is a sac the length of the finger, the fundus of which lies between the two layers of the ascending mesocolon. The orifice looks downward and to the front toward the free extremity of the cæcum,

which it is necessary to lift up in order to expose the fossa." It would seem that our own case belongs to this variety.

Moynihan describes the folds and fossæ as follows: *Primary folds*: (1) The ileocolic (or anterior vascular) fold; (2) The accessory ileocolic fold; (3) The ileo-appendicular fold; (4) The meso-appendix (mesenterium, posterior vascular fold).

The fossæ formed by these are: (1) The ileocolic fossa; (2) The accessory ileocolic fossa; (3) The ileo-appendicular fossa.

With regard to the retrocolic or retrocæcal fossa (*fossa cæcalis*, Huschke, Waldeyer; *fossæ post-cæcalis*, Tarenetzky; *subcæcal* fossa, Lockwood and Rolleston; *retrocæcal* fossa, Jonnesco; *retrocolic* fossa, Treves, Berry; *retro-versio hypogastrica dextra seu inferior dextra*, Gruber; *recessus retrocolicus*,



FIG. 1.—Retrocæcal hernia. Moynihan.

Brösike), Moynihan believes that, on the whole, the most accurate name for this fossa, and the one which he adopts, is *retrocolic*. He states: "In order to see the pouch it is necessary to turn the cæcum upward. There will then be exposed a fossa of variable size and capacity situated behind the cæcum and the lower part of the ascending colon. In some cases the whole length of the index finger can be comfortably laid in a sort of peritoneal tube which extends upward to the kidney."

In discussing the frequency of this condition, Treitz<sup>11</sup> refers to but two examples: the case of Snow<sup>12</sup> and that of Wagner.<sup>13</sup> The latter case Moynihan does not accept as authentic. He states that: "Many of the cases recorded as examples of retrocolic hernia, and accepted by most authors, including Jonnesco, cannot be regarded as authentic." He reviews sixteen such cases and gives the reasons for excluding them.

Relative to the symptoms, diagnosis, and treatment of pericæcal hernia Moynihan states as follows:

"As might be expected, a hernia into one of the fossæ around the cæcum does not actually give rise to symptoms unless strangulation occurs.

"Among the recorded cases, in but two (Atherton and Mansell Moullin) was any history of previous abdominal symptoms obtained.

"In Atherton's case the patient complained of pain and soreness in the lower part of the abdomen on the right side. These symptoms led to a diagnosis of chronic appendicitis, and the removal of the appendix. After the operation the patient developed acute intestinal obstruction, due to the strangulation of a loop of ileum in the retrocolic fossa.

"In the case recorded by Mansell Moullin the patient gave a history of four previous attacks similar to the one which proved fatal.

"In the large majority of cases the symptoms are those of acute intestinal strangulation of intestine, sudden severe abdominal pain, followed by vomiting, absolute constipation, and rapidly increasing distention of the abdomen.

"As a rule there are no means of arriving at an accurate diagnosis. In some cases resistance has been felt on palpation over the right iliac fossa.

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"In one case (Mansell Moullin) a fairly well-defined swelling could be felt, rounded above.

"Of the cases recorded, laparotomy has been performed in eight, with four recoveries and fourth deaths . . . The fact that in two of the four fatal cases (Nasse and Funkenstein) the cause of death was the inhalation of vomit, is an instructive comment on the necessity of washing out the stomach in cases of intestinal obstruction, before operating."

In operations of today it will be seen that the latest method of spinal anaesthesia would be the method of choice in such cases.

CASE.—(COLEY-HOGUET.) T. P., male, thirty-nine years of age, a carpenter, consulted Doctor Coley in August, 1928. He gave a history of having had occasional attacks of abdominal discomfort, chiefly on the right side, over a period of six or eight months. The feeling of fullness in the abdomen his family physician had attributed to gas. This discomfort slowly became more and more marked until at the end of five or six months the patient was unable to carry on his regular work. There was no loss of weight, and most of the time he was able to be up and about. The attacks of discomfort seemed to bear no relationship to his diet or exercise; they were most noticeable on lying down.

On careful physical examination Doctor Coley found a man of medium height, weighing about 150 pounds. His general appearance was that of a healthy individual. Examination of the abdomen



FIG. 2.—Showing relations of cæcum and ileum to posterior peritoneal pouch.

(prone position) showed no distention. Palpation failed to reveal any external hernia or any intra-abdominal tumor. On the right side—the side on which he had discomfort—midway between the costal arch and the crest of the ilium, on pressing down Doctor Coley could feel distinctly the sensation of bowel or omentum slipping through a ring; then on releasing the pressure he could feel the same bowel or omentum returning. It gave one the exact sensation of reducing a moderate size scrotal hernia through the inguinal ring, which required very little pressure for reduction and which, on releasing it, the sac would again refill, only the process was reversed. After several careful examinations Doctor Coley came to the conclusion that in the present case we were dealing with a retroperitoneal hernia which, when the bowel or omentum entered the sac, caused the discomfort described. Doctor Coley advised an operation. The patient was sent to the Hospital for Ruptured and Crippled, where a series of röntgenograms proved negative. Doctor Coley had a number of his colleagues examine the patient, telling them his opinion in advance, but he could get none of them to agree with it. They did agree, however, that inasmuch as the patient was suffering from some condition in the abdomen, which prevented him from carrying on his work, one was justified in performing an exploratory



operation. I was called away from town at this time and turned the patient over to my son, Doctor Hoguet and Doctor Bradley L. Coley for operation. This they performed on August 17, 1928, and their description of the procedure follows:

*Operation.*—It was thought that there might be a deficiency in the abdominal wall so a right pararectal incision was made with its centre at about the umbilicus. The fascia of the external oblique and the anterior sheath of the rectus was found to be very much thinned out in the lower half of the wound, but there was no true hernia. A long, slightly inflamed appendix was found lying in a pouch of peritoneum. This was about the size of a grape fruit. Its walls extended upward and were attached to the sides and front of the cæcum at about two inches from its lower end. (Figs. 2 and 3.) There was an opening about two inches in diameter in the anterior wall of the pouch through which about six inches of terminal ileum had herniated into the pouch. This ileum was pulled out, the walls of the pouch were cut away, and the appendix removed in the ordinary way. On account of the weakness in the abdominal wall it was closed by overlapping the fascia.



FIG. 3.—Retrocaecal peritoneal pouch containing coil of ileum and the appendix.

The patient made an uneventful recovery and is in good condition at the present time (May, 1929), nine months after the operation.

#### BIBLIOGRAPHY

- <sup>1</sup> Moynihan: Retroperitoneal Hernia. Wm. Wood & Co., N. Y.
- <sup>2</sup> Hernia: In Alb. Halleri Disput Anatom selectæ, vol. i, Diss. Inaug. de Peritone Gissæ, vol. xxiii, 1724.
- <sup>3</sup> Waldeyer: Hernia Retroperitonealis nebst Bemerkungen zur Anatomie des Peritoneum, Breslau, 1868, *Zum zweiten Male abgedruckt*, Virchows Arch., 1874.
- <sup>4</sup> Treitz: Hernia Retroperitonealis ein Beitrag zur Gesichte innerer Hernien, Prague, 1857.
- <sup>5</sup> *Loc. cit.*
- <sup>6</sup> Treves: Hunterian Lectures.
- <sup>7</sup> Toldt: Bau und Wachstumsverhältnisse der Gekröse des Menschl. Darmkanals, Denkschriften der Kais. Akademie der Wissenschaften zu Wien, February, vol. xli, 1879.
- <sup>8</sup> Santorini: Tabulæ 17. Santorini, Parma, 1775.
- <sup>9</sup> Huschke: Lehre von den Eingeweiden und Sinnesorganen des Menschl. Körpers, Leipzig.
- <sup>10</sup> Treitz: *Loc cit.*
- <sup>11</sup> Treitz: *Loc cit.*
- <sup>12</sup> Snow: London Medical Gazette, 1846.
- <sup>13</sup> Wagner: Med. Jahrbücher der K. K. Österreichischen Staats, A. J. Freiherr von Stift, vol. xii, oder neue Folge, vol. iv., Wien, 1833.

## ACUTE ABDOMINAL PAIN, ASSOCIATED WITH SPINAL CORD SHOCK

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THAT *acute*, even agonizing *abdominal pain*, accompanied by rigidity and vomiting, is at times *associated with injuries to the spinal cord*, or its nerve roots, is apparently not duly appreciated. The object of this paper, therefore, is to stress the fact that these symptoms may be due entirely to the nerve injury and that there need not necessarily be any injury to an abdominal viscus to account for such an occurrence. The following case forcibly impressed me with the importance of the necessity of recognizing the above facts.

CASE I.—A man, thirty-two years of age, was admitted to the surgical service of the Presbyterian Hospital April 2, 1927, having fallen a distance of fifty feet from a scaffold. His chief complaint on admission to the hospital was pain in the back and inability to move legs. At the time of the fall, on striking the ground, he landed on his back; he did not strike any object before hitting the ground but a heavy plank is said to have fallen across his abdomen, following him down.

He gave a history of rheumatic fever fifteen years ago. During army service in France in 1917 he was struck on the head by a wooden beam. Has been nervous and "flighty" ever since. Habitually constipated, bowels moving only once each week.

On admission he was in great pain and very badly shocked. His temperature was 97.3, pulse 66, respirations 20, blood pressure 80/20; facies is apathetic, lips cyanotic and skin cold and moist.

There was a fairly large laceration of the scalp on posterior part of skull, which had been sutured and dressed in the receiving ward—otherwise negative except for carious teeth. *Neck*.—Negative. *Chest*.—Is clear to palpation, percussion and auscultation. *Heart*.—Apex beat in fifth interspace in mid-clavicular line. First and second sounds are heard. No murmurs and no arrhythmia present. *Abdomen*.—Is scaphoid, not tender, no masses, no fluid, slight muscle guarding in both upper recti. Patient has great deal of pain in lumbar region. Tenderness over lower thoracic and lumbar spine. No deformity of spine is demonstrable.

*Extremities*.—Patient is unable to move legs. Has absence of reflexes. Anæsthesia up to six inches below the level of Poupart's ligament, and about the rectum. No loss of sensation of skin over penis but there is loss of sensation over the scrotum.

*Rectal*.—Bladder slightly distended. Sensation of fullness in the post-vesical region. Bladder catheterized sixteen ounces of urine—blood tinged. Six hours after admission.—Patient has not reacted from shock. Temperature is still subnormal, pulse slow and respirations 20. Blood pressure is still 80/20. He complains bitterly of pain in the abdomen, which is continuous. Abdomen is flat, board-like in rigidity and shows generalized tenderness. No fluid can be detected. There is an occasional flicker of peristalsis. Heart sounds resonant throughout entire abdomen. Leucocyte count 19,100, white blood cells, polymorphonuclears 89 per cent.; urine shows 200 to 300 red blood cells.

It was decided to perform an immediate exploratory laparotomy on the probability that the patient was suffering from a ruptured viscus in addition to his spinal cord shock. This was done under nitrous oxide, oxygen anæsthesia through a right rectus incision. This proved to be entirely negative, however. On the following day, patient

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vomited frequently a large amount of dark brown fluid. Stomach was washed out and a Jutte tube allowed to remain for drainage. On following day, the second following exploratory laparotomy, he was still vomiting although his general condition was fair in spite of this fact. Complete paralysis and loss of sensation of lower limbs persist. Given 500 cubic centimetres of 10 per cent. glucose in normal salt solution intravenously. Vomiting ceased on third day after accident. Again given 500 cubic centimetres of 10 per cent. glucose in normal salt solution. The neurologist to the hospital, Dr. W. B. Cadwalader, gave the following report:

"Man is completely paralyzed in both lower limbs for motion and all forms of sensation. He has retention of urine and faeces. Both limbs are flaccid. The patellar and Achilles' reflexes are absent, on each side. Irritation of soles of feet produces no movement of any kind. He cannot recognize when toes or feet are moved by the examiner. His sensation for light touch and pin prick is abolished in each lower limb as high as the line corresponding to about two inches below the anterior superior spines of the iliac bones of each side anteriorly and a corresponding point posteriorly. Cremasteric reflex is absent. This would indicate a lesion of the spinal cord or of its roots, the upper limits of which would not extend higher than the first lumbar root or segment. This would correspond to the body of the twelfth thoracic vertebra. There is marked tenderness over the ninth and tenth, eleventh and twelfth thoracic spines. The X-ray examination of today shows a crush injury of the body of the twelfth thoracic vertebra corresponding to the clinical signs of the lesion in the cord. The cord is probably crushed at this level. Would recommend laminectomy to expose this area of the cord. It is most likely that the man has had, because of this injury, hæmorrhages and destruction of the intramedullary tissues of the cord at this level. For this reason, therefore, removal of compression will probably lead to partial recovery of function but not necessarily complete recovery. I see no reason to do a lumbar puncture. Upon examination of scrotum there is impaired sensation; a sharp pin prick feels dull. There is anæsthesia about rectum. Pressing the testicle gives pain. The lesion is below the tenth dorsal segment of cord and above the sacral segment."

Given 1000 cubic centimetres normal salt solution by hypodermoclysis and 250 cubic centimetres intravenously. April 7, 1929, laminectomy was done by Doctor Rodman, eleventh and twelfth thoracic and first lumbar vertebrae exposed. Crush fracture of the twelfth thoracic vertebra found. Spines and laminae of the exposed vertebra removed. No direct pressure on cord found and no extradural bleeding. On opening dura, cord exposed for a distance of about three inches. No œdema, no hæmorrhage and no visible evidence of contusion of the cord found. Wound closed in usual way with rubber dam drain to dura (interrupted silk in dura, catgut in muscles, silkworm gut in skin). Patient reacted well from the operation.

*Progress Notes.*—The general condition of the patient improved somewhat for a time and the laminectomy wound healed by first intention, the stitches being removed on the tenth day following operation, at which time there had been no improvement in the paralysis. A cystitis developed three weeks after operation, it having been necessary to catheterize the patient since his injury. At this time the neurologist made the following note:

"Completely paralyzed for motor and sensation as before. No voluntary motion in lower limbs below the hips. Irritation of soles of feet produces no motion of any kind. There are no automatic reflex phenomena. When the lower limbs are pricked with a pin he does not feel it until the upper third of the thigh is reached anteriorly. He cannot recognize movement of the toes nor movement of the feet by examiner. Deep sensation as well as superficial sensation is abolished. He says he can feel in his lower limbs when he is being washed but I can find no evidence of the return of cutaneous sensation. His answers are misleading and he might give the impression of having sensation if the examination is not carefully made. Recovery at the present time would seem

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unfavorable but it is too soon to give a definite opinion. Partial recovery might occur; but I regard it as very doubtful."

The situation remained unchanged except that the cystitis cleared up and a bed sore at the tip of the spine appeared six weeks after injury. Seven weeks after injury, Doctor Cadwalader made the following notes:

"Examination for sensation shows that it is abolished to about the same level as before, but he can occasionally recognize pin point as painful in the anæsthetic limbs. This, however, is very irregular, uncertain and not felt in a normal manner. I would conclude that although there is an apparent slight recovery of sensation, it is by no means sufficient to warrant an opinion that any satisfactory improvement will occur. His motor paralysis has not improved."

A further neurological examination made on June 6, a little over two months after the injury, showed complete paralysis of lower limbs. Vesical and rectal paralysis. Sensation: complete anæsthesia of touch (light) up to third lumbar segment; complete analgesia (pain and pin prick) up to second lumbar—hyperalgesia above. Deep pressure sense present in feet, said to have been absent before. Slight evidence of return of sensation. Fracture of twelfth lamina without dislocation and operative findings indicate hematomyelia (hæmorrhage within cord).

Save for the fact that pressure sores developed on each heel, the patient's condition remained unchanged until his transfer to the Philadelphia General Hospital on November 28, 1927, some eight months following the injury.

In a search of the available records of the cases of spinal cord injury occurring in the hospitals with which I am connected (Presbyterian, Bryn Mawr and Woman's College Hospitals of Philadelphia), only one other case was found in whom abdominal pain was present. This record is as follows:

CASE II.—A man, thirty-nine years of age. On the night of December 8, 1928, patient jumped out of a second-story window in an attempt at suicide. He was brought to the Presbyterian Hospital and on admission was complaining of severe abdominal pain in the right hypochondrium. At that time he was in a condition of mild surgical shock and was admitted to Dr. E. B. Hodge's service. Because of the abdominal pain and marked rigidity a rupture of the liver was suspected. He was mentally confused and had sustained also a laceration of the scalp. In about two hours the abdominal pain and rigidity in the right hypochondrium had subsided, and the patient's color had returned to normal, but he was detained for further observation. Blood pressure 120/85. The detailed history and physical examination will not be repeated here. In the light of the subject under discussion the only relevant facts are that he is single, has been very nervous and uses alcohol to excess. There is tenderness over the lower lumbar region of the back showing on the left side an area of ecchymosis. Palpation here reveals some tenderness. There was no paralysis or altered sensation in lower extremities, although both knee-jerks were markedly diminished. No Babinski or ankle-clonus. The elbow-jerks were entirely absent bilaterally. An X-ray of the lower lumbar spine and pelvis revealed a fracture of the lateral processes of the third and fourth lumbar vertebræ as well as slight tearing of the rim of the left acetabulum. Lumbar puncture obtained clear cerebrospinal fluid under twenty millimetres hæmoglobin pressure. The blood Wassermann was negative as was the Kahn precipitation test. The neurologist's report expressed the opinion that the patient was in all probability suffering from an alcoholic psychosis with the possibility of a beginning paresis.

In a somewhat exhaustive search through the literature I have been unable to find another case in which abdominal pain and rigidity complicating spinal cord injury was so severe as to lead to an abdominal exploration. The fact that this was done in the first of the two cases now being placed on record

and that the abdominal findings were entirely negative is, so far as I am able to determine, the first absolute proof that such symptoms can occur without injury to any abdominal viscus. One finds mention of either abdominal pain, rigidity or vomiting associated with spinal cord injury in a few isolated cases similar to the second case here reported in which the experience of the first case was of great help in determining the course of watchful waiting during which these symptoms disappeared. Thus in the third case reported as one of a series of three showing spinal cord injury by Brickner and Milch,<sup>1</sup> abdominal rigidity and later distention was a part of the clinical picture in a case showing fractures of the eleventh dorsal and the first and second lumbar arches, as well as the left lateral process of the second lumbar vertebra. In this case laminectomy was done exposing the cord from the eleventh dorsal to the third lumbar vertebræ and a clot was removed from about the cauda equina which was found very cedematous but otherwise intact.

It has long been known that abdominal pain may be caused by extra-abdominal lesions and that, *vice versa*, abdominal lesions themselves may cause extra-abdominal pain. We are all entirely familiar with the difficulty, at times, in making a differential diagnosis between pneumonia, especially of the lower lobes, and appendicitis. Especially has this difficulty been increased in my experience in the extremes of life. Goldbloom<sup>2</sup> states that while it is well recognized that such lesions as pericarditis and pleuritic effusions may be associated with abdominal pain that this association is not nearly so well appreciated in other, even more common, extra-abdominal diseases as tonsillitis, the infectious fevers, etc. He further states that empyema caused such "dominant" abdominal symptoms in two of his cases as to lead to the diagnosis of peritonitis being seriously considered. In both of these cases, the abdominal symptoms quickly subsided after thoracotomy. The acute pain referred to the abdomen in the gastric crisis of tabes has led to negative findings by laparotomy as we know. Peck<sup>3</sup> states that he has seen gastroenterostomy performed in such cases and refers to other extra-abdominal lesions causing severe abdominal pain as the thoracic ones mentioned above, angina pectoris and thoracic aneurysm.

Undoubtedly the most important contributions made to the understanding of traumatic lesions of the spinal cord were those made by Riddoch<sup>4</sup> and Head<sup>5</sup> in 1917 when they published a detailed study of cases in whom the cord had been divided at varying levels by war injuries. It is to them that we owe our present-day conception of spinal cord shock. These studies made definitely clear the fact that the spinal cord does not regenerate after injury but that many reflex acts, as partially emptying the bladder, reappearance of the patella tendon reflexes and reflex movements of the lower limbs, may be found in the stage of "mass reflex" which occurs after complete division of the spinal cord. Such a stage of "mass reflex" may last many months, indeed many years, as in the case originally reported by Stewart and Harte<sup>6</sup> and studied nineteen years later by Cadwalader.<sup>7</sup> There is no reference in



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these epoch-making articles, however, of such acute abdominal pain having been present as was observed in the first of the cases herein reported.

It is quite beyond the scope of this paper to attempt a complete explanation of acute abdominal pain, due solely to spinal cord injury. This matter has engaged the attention of some of our best neurological minds recently. We know that pain and temperature fibres enter the cord *via* the posterior nerve roots and then cross the commissure to ascend to the thalamus *via* the anterolateral tracts of the opposite side. It has been believed that in the dorsal region one or two segments only are necessary for such crossing and that four to six segments in the cervical region may be so involved. The recent views of Forster, however, make it seem likely that this crossing is immediate. Head, Elsberg, Forster and others have shown that as these fibres ascend they may occupy a lamellar position. Pollock and Davis<sup>8</sup> in recalling Holmes' study of unilateral lesions of the spinal cord state that from his observations it could be concluded that the fibres from the lower segments occupy a position lateral to those from the upper. They believe that in intramedullary tumors of the upper dorsal region the fibres conducting pain, heat and cold are distributed from within outward.

This matter of the association of abdominal pain with spinal cord lesions came in for a part of the discussion during the German Neurological Congress, at Vienna, in 1927. Thus Schwab<sup>9</sup> states that section of the cord at the first dorsal segment abolishes all pain in the internal organs of the chest and abdominal cavity while at the sixth dorsal segment section abolishes pain in the organs of the abdominal cavity and pelvis. Forster<sup>10</sup> is of the opinion that pain from the abdominal organs is carried largely by way of the sympathetic nervous system, especially over the peri-arterial net of the aorta and the visceral arteries. It is uncertain, he thinks, whether and to what degree the afferent fibres of the vagus and the phrenic nerves also serve as pain transmitters.

While not so prominent a feature as pain, abdominal rigidity was present to a marked degree in the first of the two cases here reported and partially, at least, led to the presumption that there had been an intra-abdominal injury. A. Hoffmann<sup>11</sup> found that rigidity of the abdominal walls is usually due to a reflex action through the intercostal and lumbosacral nerves; while, therefore, it is usually produced when the parietal peritoneum is irritated it may be easily produced through direct action on the intercostal and lumbosacral nerves, as occurs for example in kidney injuries when there is inflammation in the region of the spine. Irritation of the posterior roots may also produce rigidity and thus lead to errors in diagnosis. Hoffmann states that many a case of gunshot injury to the kidney or of perinephritic abscess has been subjected to laparotomy because the abdominal rigidity suggested that one was dealing with an intra-abdominal lesion. He quotes Weil as stating that in the literature cases of crushing wounds of the vertebral column are reported in which this symptom was present to a high degree. Since, therefore, abdominal rigidity is a reflex process, it follows that it occurs in irri-

tations of the parietal peritoneum as long as the short reflex arc is intact, *i.e.*, it will occur even after section of the spinal cord in the middle or upper thoracic segment. It has been known, although perhaps not generally appreciated, that disease of or changes in the abdominal walls might be responsible for abdominal pain and rigidity. We are familiar with the fact that intercostal neuralgia may closely simulate the symptoms of chronic appendicitis; J. B. Carnett<sup>12</sup> having stressed this fact. Two cases are reported by Poniemunski<sup>13</sup> in which these symptoms were due to changes in the wall and injury to the intercostal nerve in connection with resection of the ribs.

In the first of the two cases which I am now reporting the diagnosis of traumatic hæmatomyelia has been substantiated beyond reasonable doubt. This opinion, originally expressed by the neurologist to the hospital, Doctor Cadwalader, was made more certain when I failed to find damage to the cord itself in performing a laminectomy as included in the case history. The present condition of the patient about one year after operation is substantially the same as when operated upon. He does, however, complain occasionally of a numb, burning sensation on irritation of the skin of the lower limbs. This phenomenon resembles that described by Forster and others to which the name "hyperpathia" has been given and is rather characteristic of incomplete destruction of the pain fibres in the anterolateral regions of the cord in these traumatic cases.

Since the subjective sensation of pain must depend upon the cerebral registration of afferent impulses, it follows that only in such incomplete lesions is it possible. Complete anatomical section of the cord does not cause pain because of this fact. The fact, also, that at no time has this man established a complete stage of "mass reflex" makes us feel all the more certain that the diagnosis of hæmatomyelia is correct, for Riddoch believes that it is only in complete transverse cord destruction that "mass reflex" is fully established.

I believe that the explanation of the acute abdominal pain and muscle rigidity in this case, then, is in all probability due to irritation of the posterior roots by the crush fracture of the twelfth thoracic vertebra. It seems unlikely that the autonomic nervous system played an appreciable part in the production of the pain in this case, since pain arising from this source is thought to be dull in character and not nearly so severe as in this instance. It is true that a heavy board is said to have struck him across the abdomen, following him downward in his fall. Had this pain been less severe and more immediate, we might have attached more importance to this fact but believe that nothing short of root irritation could have been responsible for such extreme agonizing pain as this man complained of. Surgical shock as well as spinal cord shock no doubt played a part in the delay of the onset of the pain. Absence of reflexes at this time in the lower extremities with complete paralysis attest the latter, as the well-known picture of surgical shock showed this to be present.

I repeat that the principal object of this paper is to stress the fact that severe abdominal pain, rigidity and vomiting may occur as the result of spinal

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cord injury alone, and need not necessarily be accompanied by any intra-abdominal lesion.

### REFERENCES

- <sup>1</sup> Brickner, W. M., and Milch, H.: Internat. Clin., vol. iv, pp. 239-246, Phila., 1926.
- <sup>2</sup> Goldbloom, Alton: Abdominal Pain in Children in Extra-Abdominal Conditions. Canad. M. Ass. J., vol. xvi, pp. 1223-1230, Toronto, 1926.
- <sup>3</sup> Peck, Chas. H.: Pain in the Upper Abdomen and Chest. Surgery, Gynecology and Obstetrics, pp. 220-322, February, 1924.
- <sup>4</sup> Riddoch: Brain, vol. xi, p. 264, 1917.
- <sup>5</sup> Head: Brain, vol. xi, p. 188, 1917.
- <sup>6</sup> Stewart, Francis T., and Harte, Richard H.: Phila. Med. Jour., June 7, 1902.
- <sup>7</sup> Cadwalader, William B.: ANNALS OF SURGERY, June, 1920.
- <sup>8</sup> Pollock, L. J., and Davis, L. E.: Injuries of the Spinal Cord. Illinois Med. Jour., September, 1921.
- <sup>9</sup> Schwab: Archives of Neurology and Psychiatry, November, 1928.
- <sup>10</sup> Forster: *Ibid.*
- <sup>11</sup> Bruns: Beitrage, vol. clxix, p. 701, 1910.
- <sup>12</sup> Carnet, J. B.: Surg., Gyn. and Obs., pp. 625-632, May, 1926.
- <sup>13</sup> Poniemunski, H.: Med. Klin. Berl. and Vien., vol. xxii, 1926.

## SOME UNUSUAL TYPES OF ABDOMINAL HÆMORRHAGE \*

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I AM reporting four cases of abdominal hæmorrhage of unusual interest and considerable rarity, which caused a serious emergency and called for immediate operation.

1. Intraperitoneal hæmorrhage due to a teratoma of the ovary.
2. Intraperitoneal hæmorrhage due to spontaneous rupture of the liver.
3. Hæmorrhage into the abdominal wall due to spontaneous rupture of the deep epigastric artery.
4. Fatal spontaneous extraperitoneal hæmorrhage in a hæmophilic.

CASE I.—*Intraperitoneal hæmorrhage due to a teratoma of the ovary.* Miss D., seventeen years of age, white. February 1, 1926, she complained of severe crampy pains low down in the abdomen, which her mother thought were due to the onset of her menstrual period. Two days later her physician was called, and attributed the pain to uterine contractions. It subsided with a sedative and she was quite well until a fortnight later when she was seized with severe pain over the lower abdomen, and was sent into the Wellesley Hospital.

*Examination on Admission.*—She was decidedly masculine in appearance, with deep voice and moderate growth of hair on the face; skin pale; temperature 101° F., pulse 140; heart sounds normal; a few râles at the bases of the lungs; leucocyte count 25,600; polymorphonuclears 88 per cent.; urine negative. Both recti on guard; abdomen doughy to the touch, with tenderness on both sides below the umbilicus, more marked on the right than the left. Liver dullness present.

Vaginal examination under anæsthetic showed the clitoris to be about four times the normal size with a well-developed glans. The labia were poorly developed. The pubic hair had the masculine distribution. The uterus was very small, and on its right side an elastic mass the size of a goose egg could be felt.

On opening the abdomen about four ounces of dark red blood exuded. A tumor about the size of a tangerine orange was seen lying to the right of the uterus, with a loop of small intestine adherent to it. It had the appearance of a tubal gestation. After separating the gut and freeing the mass from the right cornu of the uterus, the growth was found to involve the right ovary only. The whole mass was removed, when the capsule of the growth was found to be ruptured, with blood and necrotic material oozing from its upper surface. One thousand cubic centimetres of 5 per cent. glucose was given intravenously on the table.

She made good progress for about a week, when signs of internal hæmorrhage appeared, and examination revealed the left chest flat on percussion, with distant and feeble breath sounds. The temperature rose to 106° F. She became rapidly weaker, and died March 1, fourteen days after the operation.

A complete post-mortem examination was not permitted, but the abdominal incision was enlarged. Nothing of note was found in the peritoneal cavity. The diaphragm was detached from the ensiform cartilage and incised vertically and laterally. When the left pleural sac was opened about two quarts of fluid blood ran out. The lung was represented by a hard fibrous mass the size of a grapefruit, densely adherent to the parietal pleura, the adhesions being so strong that all the lung could not be removed. The right lung was smaller than normal, and invaded with dark areas. There was no blood in the

\* Read by title.

## UNUSUAL TYPES OF ABDOMINAL HÆMORRHAGE

pleural cavity. The heart and pericardium were normal in appearance. The lungs were removed for microscopic examination. She had bled to death into her left pleural cavity.

The following report was given by Dr. G. W. Lougheed, Pathologist to the Wellesley Hospital: Microscopic examination shows the lung to present two distinct pictures. The greater portion is extremely hæmorrhagic, the alveoli being filled with red blood cells, and there is some œdema. Other portions of the lung show the alveoli filled with groups of small cubical cells several layers deep, which resemble closely Langhans's cells of the chorion. Covering these are large multinucleated cells which stain deeply and look like typical syncytial cells. Surrounding both these embryonic cells are areas of hæmorrhage.

*Diagnosis.*—"Chorion epithelioma" of the lung secondary to teratoma of the ovary. Doctor Lougheed examined the tumor removed at operation, and reported as follows: Tissue received consists of an irregular ovarian tumor about two inches in diameter, together with the tube. On section the cut edge of the ovarian tissue is dark red in color and very friable. There are areas which appear to be necrotic. The tube is attached to the ovary, and at this point there is a hard mass the size of a hazel nut. This appears to be either new formed bone or a calcareous deposit.

Slides made from the ovarian tissue show definite rudiments of viscera, skin, sweat glands, cartilage and ganglion cells. There are also groups of atypical vesicular cells rapidly proliferating, and showing numerous atypical mitotic figures. Other cells are more adult in character, and show a tendency to pearl formation.

There are still other groups of cells of the lymphoid type. Interspersing these are numerous young blood vessels which have ruptured, flooding the areas with blood. The capsule of the ovary proper is eroded by the vesicular cells which are multinucleated and have the appearance of being the syncytial cells of the chorion.

*Diagnosis.*—Teratoma of the ovary undergoing chorionic epitheliomatous change.

Bland-Sutton defines this tumor as an irregular conglomerate mass containing the tissues and fragments of viscera belonging to a suppressed fœtus attached to an otherwise normal individual. He accounts for its occurrence by suggesting that the teratoma and the autosite are conjoined twins, the tumor of course being the result of incomplete development. MacCallum supports the theory that they arise from isolated blastomeres, and gives



FIG. 1.—Low power. Lung tissue.



many excellent reasons for this view, but until we understand the processes of parthenogenesis and the pathogenesis of tumors in general, the origin will remain a matter of speculation.

The occurrence of ovarian teratomata is fairly common, being given as from 4 to 18 per cent. of all ovarian tumors, but if dermoids be excluded, even the lowest of these figures, in our experience, is too high.

Morphologically, the ovarian ones are composed of all tissues, though liver, pancreas, testicle and ovary are not represented. As each tumor is unique in its composition it would tend to confirm the hypothesis of origin given above as supported by MacCallum, because as he says, should they arise from fertilized polar bodies or primary sex cells, one would expect more uniform and complete representation of tissue.

As in the case of other unusual abdominal tumors, the pre-operative diagnosis is very seldom made, surgery becoming imperative in consequence of rupture or other disturbance due to the size of the growth or its metastatic involvement.



FIG. 2.—Low power. Ovarian tissue.

CASE II.—*Intraperitoneal hemorrhage due to spontaneous rupture of the liver.* Miss N., forty years of age, trained

nurse. For the last year she had suffered from indigestion and malaise, and about two months ago consulted her physician who diagnosed cholecystitis and gave her a special diet. She did not improve, and since then had only been able to do half-time duty.

On the day of admission she was suddenly seized with very severe abdominal pain on the right side of her abdomen and extending through to the back. It was of a steady stabbing nature and was soon followed by collapse. When her physician arrived he found her almost in extremis, with cold skin, small pulse and marked pallor, and after administering stimulants sent her into the Wellesley Hospital.

On admission she was suffering great pain in spite of one-half grain of morphia, from which her pupils were still tightly contracted; the skin was slightly jaundiced and the pulse was 160, small and thready.

*Abdominal Examination.*—A board-like rigidity was present on the right side, extending into the right flank, with extreme tenderness on palpation over the whole right side. The liver dulness was markedly increased, the lower edge being a hand's-breadth below the costal region.

*Urine Examination.*—Three plus albumen, with hyaline casts and some pus cells. Temperature 97.4°.

*Diagnosis.*—A ruptured viscus—probably gall-bladder.

Laparotomy with regional anaesthesia. On opening the abdomen a large amount of

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blood gushed out and there was a noticeable absence of clots. The liver appeared to occupy the whole of the right side and was purplish in color; the capsule very tense, and the interlobular markings absent. On the anterior surface, immediately below the costal margin, was a transverse laceration two and one-half inches in length, gaping widely.

As the patient was practically moribund the opening in the liver was quickly packed with gauze and the abdomen closed. One thousand cubic centimetres of 5 per cent. glucose was given intravenously.

Following the operation she had a great deal of abdominal pain which could not be entirely relieved. The urine contained large amounts of tyrosine and leucine. The bowels functioned well with enemata, but she never properly rallied, and succumbed on the third day.

A partial post-mortem was obtained which showed the liver to be twice its normal size; the capsule very tense, and the substance rubbery. The spleen was normal in size, had no adhesions surrounding it, and all the other abdominal structures were normal.

On making a section of the liver one found a great many greenish-white areas mixed with purplish looking liver substance, and the microscopic appearance shown below is that of a marked diffuse hepatitis.

The slide shows atrophy of groups of the liver lobules, which are replaced by fibrous tissue, red blood cells and lymphocytes. The remaining liver lobules show marked cloudy swelling. The central and the perilobular veins are markedly congested and dilated with red blood cells. The bile capillaries show early proliferation and infiltration with lymphocytic and endothelial cells.

*Diagnosis.*—Acute hepatitis with early atrophy.

This type of case occurs not infrequently. The surgeon is asked to operate in a case of hæmorrhage or ascites, or when the diagnosis is obscure.

The pathological changes which occur in the liver in lesions of a toxic origin, according to Mallory, do not differ essentially from changes occurring in tissues elsewhere from the same cause, and for this reason he suggests that the terms "acute yellow atrophy, cirrhosis," etc., should be abolished and the conditions indicated in the term "hepatitis."

*CASE III.*—Hæmorrhage into the abdominal wall due to spontaneous rupture of the deep epigastric artery. Mrs. M., thirty-nine years of age, two para. Now about six and



FIG. 3.—Low power. Liver.

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one-half months pregnant. Has always enjoyed good health. After her usual day's housework was sitting at dinner when she was suddenly seized with very severe pain in the right side, and collapsed. Her physician was summoned and found a rapidly increasing tumor in the right iliac region, which he thought due to a ruptured uterus, and sent her immediately into the Wellesley Hospital.

On admission the tumor was about the size of a cocoanut.

Pelvic examination was not very satisfactory on account of the great pain from which the patient was suffering, but she was thought to have a ruptured uterus and was immediately prepared for operation.

The incision was made a little to the right of the mid-line, over the centre of the tumor. When the sheath of the rectus muscle was incised blood shot out with great force as it was under terrific pressure. The hæmorrhage was found to be coming from the deep epigastric artery which had stripped up the muscle from its posterior sheath over a large area. This stripping process had been carried out into the flank, forming a large hæmatoma. The artery was ligated, the blood clot removed, and the cavity lightly packed with gauze. It was not necessary to open the peritoneum.

She made an uninterrupted recovery and gave birth to a living child at the end of ten days.

This condition is apparently very rare, as none of our obstetricians in Toronto had seen a similar case.

CASE IV.—*Fatal spontaneous extra-peritoneal hæmorrhage in a hæmophiliac.* Mr. R., forty-six years of age. He was suddenly taken with pain in the left lower quadrant of the abdomen, and the following day a mass appeared which could be felt upon rectal examination. With a sigmoidoscope, ecchymosis of the rectal wall was seen about three inches up the rectum.

I saw him for the first time three days later, when he was on the operating table. His pulse was rapid, and a swelling could be seen occupying the left iliac, hypogastric and umbilical region, which was dull on percussion.

The abdomen was opened in the mid-line and nothing found within the peritoneal cavity, but a large collection of blood clot was outside the peritoneum, where fresh oozing of blood was going on. We thought it might be due to a sarcoma, but owing to its being so widespread nothing could be done beyond packing the cavity with gauze. Transfusions were given, with no benefit, and he died three days later.

Post-mortem examination revealed a large collection of clotted blood separating the peritoneum from the parietal wall in front as high as the umbilicus, and extending backward and upward until the diaphragm was reached. No evidence of a growth was found.

After the operation we got a history of his having been hit with a stone on his left eyebrow three years previously, when great difficulty was experienced in stopping the bleeding. He was evidently a hæmophiliac.

## GLUCOSE TOLERANCE AND HEPATIC DAMAGE

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MANY methods have been suggested for determining the functional capacity of the liver. The liver has many functions, consequently it is unlikely that any one test will measure accurately its total physiological capacity. Since Claude Bernard discovered the important part played by the liver in carbohydrate metabolism through the storage of glycogen, many attempts have been made to determine liver function by the observation of variations in body reactions to different sugars. Most of these tests have been discarded because of unreliability or lack of specificity. We believe it probable that information of clinical value concerning the glycogenetic function of the liver can be obtained by a new interpretation of the usual glucose tolerance test.

Strauss<sup>1</sup> in 1901 proposed levulose as a test for hepatic function, studying its appearance in the urine after the ingestion of 100 grams by mouth, but later observers summarized by Rountree, Hurwitz, and Bloomfield<sup>2</sup> discard it as of no clinical value. With the development of methods for the determination of blood sugar there has been a renewed interest in the levulose test, well summarized by Greene *et al.*<sup>3</sup> Spence and Brett<sup>4</sup> report definite changes in blood sugar curves following the ingestion of levulose by patients with hepatic disorders. Bodansky<sup>5</sup> studied the tolerance of normal dogs for glucose, levulose and galactose. He found that levulose is less effective and galactose more effective than glucose in producing alimentary hyperglycemia. He<sup>5</sup> then studied carbohydrate tolerance in experimental liver derangements due to chloroform and phosphorus poisoning, finding the levulose tolerance tests valuable in measuring liver involvement in these conditions. Lowered tolerance for glucose and galactose was likewise associated with severe liver injury, but he states that glucose cannot be used as a function test because other factors may influence the tolerance for this carbohydrate. The occurrence of hypoglycemia following hepatic poisons has been shown by Frank and Isaac,<sup>7</sup> using phosphorus in rabbits; Williamson and Mann<sup>8</sup> in dogs following the administration of chloroform and phosphorus. Izume and Lewis<sup>9</sup> found hypoglycemia in rabbits after administration of hydrazin and state that this is due to a failure of normal glycogenesis as a result of which the supply of glucose available is diminished because of injury to the liver. Mann<sup>10</sup> in his extensive studies of physiology following total removal of the liver showed a constant decrease in blood sugar levels and a close correlation between this level and the clinical condition of the animal. Mann and Bollman<sup>11</sup> studying partially hepatectomized animals found the blood sugar levels decreased, but regardless of the amount removed an adequate level was always maintained and the rate of recovery of the blood sugar level was prolonged after the removal of a considerable portion of the liver. The study of function following partial hepatectomy is difficult because of the great regenerative power and the excess capacity of the liver. Fishback<sup>12</sup> has shown that regeneration occurring as hypertrophy of the remaining lobes will be complete in from six to eight weeks with an actual restoration of four-fifths of normal weight and volume.

# COLLER AND TROOST

After we had observed distinct variations from the normal glucose tolerance curves in patients with known liver damage we studied the behavior of this standard test in animals whose livers had been injured by partial removal or by hepatic poisons. Normal dogs were given glucose tolerance tests, after which portions of the liver were removed at intervals, and the glucose tolerance again studied. In determining the glucose tolerance the following method was used: The dogs were fasted for twenty hours before the beginning of the test. The fasting blood specimen was withdrawn from a vein. There was 1.75 grams of glucose per kilogram of body weight given in 100 cubic centimetres of water by stomach tube. At intervals of

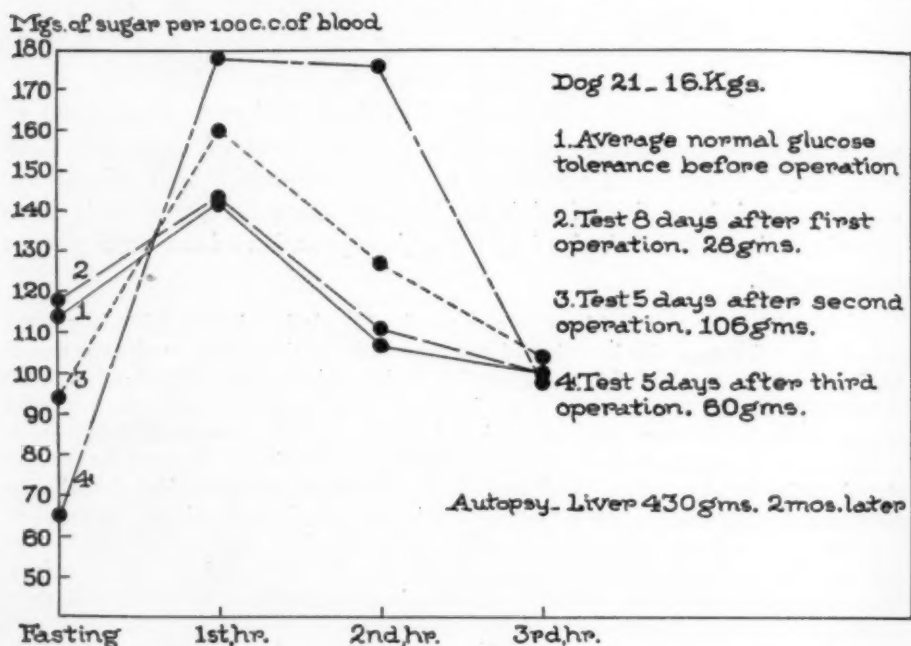


FIG. 1.—Graphic representation of Table I, showing alterations in shape of curve with each increment of liver removed.

one, two, and three hours blood specimens were withdrawn using sodium citrate as an anticoagulant. The blood filtrates were made immediately after the blood was withdrawn and kept in an ice box until the completion of the test. The blood sugar was then determined by the Folin-Wu method. All operations were done through a median incision under complete ether anesthesia. The lobe lightly held in clamps was resected beyond them and the stump ligated in continuity. Blood sugar determinations were not made till at least three days after operation to allow the possible variations associated with the operation to disappear. Every endeavor was made to maintain nutrition at a normal level. The results of these studies in four dogs are shown in Tables I to IV.

When glucose in this amount is taken into the alimentary tract of a normal fasting individual there is found at the end of one hour from .15 to



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.17 per cent. blood sugar. At the end of two hours this amount has dropped to about .12 per cent. and at the end of the third hour the amount has

TABLE I

*Glucose Tolerance Tests with Three Operations on Liver*

Dog No. 21

| Date                   | Weight in kilograms                  | Milligrams sugar per 100 cubic centimetres |        |         |         |
|------------------------|--------------------------------------|--|--------|---------|---------|
|                        |                                      | Fasting                                    | 1 hour | 2 hours | 3 hours |
| November 18, 1927..... | 16.5                                 | 111  | 138    | 105     | 93      |
| November 22, 1927..... | 16.5                                 | 117  | 146    | 109     | 116     |
| November 29, 1927..... | Operation—28 grams of liver excised  |  |        |         |         |
| December 7, 1927.....  | 16.                                  | 118  | 143    | 111     | 100     |
| December 21, 1927..... | 16.1                                 | 108  | 140    | 97      | 105     |
| December 28, 1927..... | Operation—106 grams of liver excised |  |        |         |         |
| December 31, 1927..... | 15.7                                 | 94   | 160    | 127     | 104     |
| January 4, 1928.....   | 15.5                                 | 107  | 158    | 112     | 104     |
| January 11, 1928.....  | 15.5                                 | 76   | 129    | 98      | 74      |
| January 21, 1928.....  | 15.4                                 | 79   | 120    | 85      | 77      |
| February 29, 1928..... | 14.5                                 | 64   | 103    | 91      | 68      |
| March 3, 1928.....     | Operation—61 grams of liver excised  |  |        |         |         |
| March 8, 1928.....     | 14.2                                 | 65   | 178    | 176     | 98      |
| March 10, 1928.....    | 14.                                  | 63   | 167    | 151     | 89      |
| March 15, 1928.....    | 14.4                                 | 60   | 123    | 79      | 63      |
| March 21, 1928.....    | 15.                                  | 56   | 110    | 65      | 65      |
| April 17, 1928.....    | 14.5                                 | 57   | 103    | 60      | 61      |
| May 21, 1928.....      | 14.                                  | 65   | 105    | 68      | 63      |
| May 23, 1928.....      | Operation—65 grams of liver excised  |  |        |         |         |
| May 24, 1928.....      | Animal died. Liver weight 430 grams  |  |        |         |         |

returned to approximately the fasting level. When injury to the pancreas exists the fasting blood is abnormally high and following the ingestion of

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glucose remains high in the second and third hours instead of showing the normal decline. This has been called the diabetic type of curve. In the absence of injury to the carbohydrate mechanism one occasionally obtains a type of curve in which the fasting level is normal but which reaches an abnormal height at the end of the first hour but which has been restored to normal levels at the end of the second hour. (Emotional hypoglycemia.)

TABLE II  
*Glucose Tolerance Tests with Two Operations on Liver*

Dog No. 1

| Date              | Weight in kilograms                             | Milligrams per 100 cubic centimetres |        |         |         |
|-------------------|---|--------------------------------------|--------|---------|---------|
|                   |   | Fasting                              | 1 hour | 2 hours | 3 hours |
| August 6.....     | 9.3   | 109                                  | 158    | 109     | 133     |
| August 10.....    | 9.3   | 111                                  | 160    | 095     | 100     |
| August 11.....    | 9.3   | 08 ?                                 | 150    | 108     | 100     |
| August 12.....    | Operation—left lobectomy—75 grams liver excised |                                      |        |         |         |
| August 21.....    | 8.4   | 125                                  | 215    | 220     | 084     |
| August 23.....    | 8.3   | 107                                  | 178    | 176     | 120     |
| August 27.....    | 8.2   | 116                                  | 222    | 137     | 084     |
| September 1.....  | 8.  | 105                                  | 181    | 105     | 100     |
| September 2.....  | Operation—left lobectomy—66 grams liver excised |                                      |        |         |         |
| September 8.....  | 7.6   | 09 ?                                 | 230    | 238     | 086     |
| September 20..... | 7.4   | 105                                  | 215    | 230     | 094     |
| December 1.....   | 9.0   | 070                                  | 160    | 106     | 086     |
| December 3.....   | Died during operation—Liver weight 210 grams    |                                      |        |         |         |

In Table I it may be noted that following the removal of twenty-five grams of liver the glucose tolerance remains unchanged. Following the second operation with the removal of 106 grams of liver there is a slight drop in the fasting level. The slight derangement of the curve noted during the first week after operation begins to be compensated for and in two weeks the curve is of a normal shape except for the low fasting level. Following the third operation with the removal of sixty-one grams of liver there was no further decrease in the fasting level which, however, remained persistently low. Determinations made five and ten days after the third operation show a marked prolongation of the curve since the level at the second hour is at about the same height as it was at the first hour. As regeneration occurs the

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TABLE III  
*Glucose Tolerance Tests with Two Operations on Liver*

Dog No. 40

| Date                   | Weight in kilograms   | Milligrams per 100 cubic centimetres |        |         |         |
|------------------------|---|--------------------------------------|--------|---------|---------|
|                        |   | Fasting                              | 1 hour | 2 hours | 3 hours |
| December 30, 1928..... | 7.5   | 106                                  | 123    | 98      | 106     |
| January 4, 1928.....   | 7.5   | 110                                  | 132    | 105     | 107     |
| January 7, 1928.....   | Operation—73 grams of liver removed   |                                      |        |         |         |
| January 10, 1928.....  | 7.2   | 104                                  | 164    | 168     | 127     |
| January 13, 1928.....  | 7.3   | 90                                   | 141    | 130     | 88      |
|                        | Tests were discontinued after this date as the abdominal incision had opened. Tests were started again when the wound had healed. |                                      |        |         |         |
| March 21, 1928.....    | 7.5   | 84                                   | 110    | 80      | 81      |
| April 26, 1928.....    | 7.5   | 81                                   | 105    | 85      | 83      |
| April 28, 1928.....    | Operation—animal died during the operation<br>Autopsy—liver weight 223 grams  |                                      |        |         |         |

TABLE IV  
*Glucose Tolerance Tests with One Operation on Liver*

Dog No. 22

| Date                   | Weight in kilograms                               | Milligrams per 100 cubic centimetres |        |         |         |
|------------------------|---|--------------------------------------|--------|---------|---------|
|                        |   | Fasting                              | 1 hour | 2 hours | 3 hours |
| November 18, 1927..... | 12  | 97                                   | 142    | 102     | 104     |
| November 22, 1927..... | 12  | 100                                  | 138    | 91      | 103     |
| December 2, 1927.....  | Operation—67 grams of liver excised               |                                      |        |         |         |
| December 7, 1927.....  | 11.8  | 106                                  | 160    | 155     | 125     |
| December 20, 1927..... | 11.5  | 88                                   | 143    | 125     | 79      |
| January 7, 1928.....   | Operation—81 grams of liver excised               |                                      |        |         |         |
| Januray 10, 1928.....  | 11  | 94                                   | 166    | 163     | 130     |
| January 11, 1928.....  | Animal died of hæmorrhage. Liver weight 232 grams |                                      |        |         |         |

level of the second hour is reduced until it arrives at a normal point. This is noticeable to lesser degree following the second operation. These changes are shown graphically in Figure 1. In Table II there are found alterations in the shape of the curve following the first operation similar to those seen in Table I. One week following the first operation the level at the second hour is slightly higher than that of the first hour. During the following five weeks it was restored to a normal level. Following the second operation the level of the second hour is again raised and is somewhat slower in its return to a normal level. Table III shows the prolongation of the curve following operation with an eventual restoration to normal at the second

Mgs. of sugar per 100 c.c. of blood

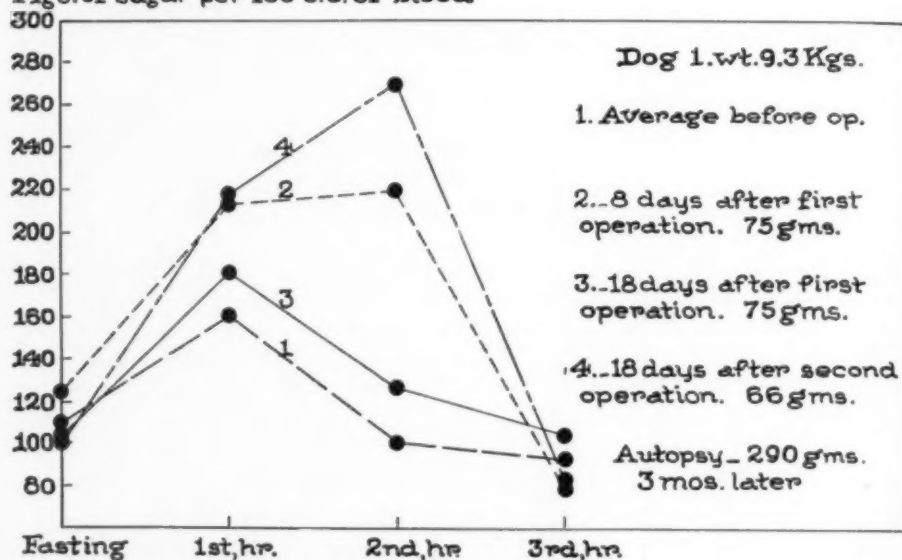


FIG. 2.—Graphic representation of Table II, showing plateau top of curve following each operation.

hour. A slight lowering of the fasting level occurs. Table IV shows a similar type of curve with a high second hour level following both operations. No marked change in fasting level occurred but the experiment was a short one. The prolongation of the curve after each operation is marked.

Much experimental work has been done in studying carbohydrate metabolism following the administration of hepatic poisons. The method is open to criticism in that other organs may also suffer damage. In order to compare the results of this method of producing liver injury with the method already used and also to study the reaction of liver thus injured to the standard glucose tolerance test with the same time elements, dogs were given chloroform in oil subcutaneously. The results in two dogs are seen in Table V. Dog No. 52 shows a marked fasting hypoglycemia with marked prolongation of the curve as shown by the high sugar levels in the second and third hours. In Dog No. 53 a marked hypoglycemia is also observed. The flat curve suggests failure to absorb glucose in this animal. A com-

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parison of the amount of damage done to the liver of each dog is impossible so that no conclusions can be drawn. Bodansky<sup>6</sup> found the reaction in

TABLE V  
*Glucose Tolerance Tests with Chloroform Poisoning*

Dog No. 52

| Date                  | Weight in kilograms   | Milligrams per 100 cubic centimetres |        |        |        |
|-----------------------|---|--------------------------------------|--------|--------|--------|
|                       |   | Fasting                              | 1 hour | 2 hour | 3 hour |
| January 18, 1928..... | 18  | 104                                  | 127    | 98     | 101    |
| January 19, 1928..... | 18  | 101                                  | 125    | 105    | 99     |
| January 21, 1928..... | 12 cubic centimetres of chloroform in 12 cubic centimetres of oil injected subcutaneously |                                      |        |        |        |
| January 23, 1928..... | 18.2  | 64                                   | 104    | 97     | 86     |
| January 25, 1928..... | 18.3  | 66                                   | 137    | 164    | 130    |
| January 27, 1928..... | 18.3  | 69                                   | 153    | 168    | 141    |
| January 28, 1928..... | Animal was killed this date   |                                      |        |        |        |

Dog No. 53

| Date                  | Weight in kilograms   | Milligrams per 100 cubic centimetres |        |        |        |
|-----------------------|---|--------------------------------------|--------|--------|--------|
|                       |   | Fasting                              | 1 hour | 2 hour | 3 hour |
| January 18, 1928..... | 14.5  | 102                                  | 120    | 98     | 105    |
| January 19, 1928..... | 14.4  | 106                                  | 128    | 100    | 98     |
| January 21, 1928..... | 10 cubic centimetres of chloroform in 10 cubic centimetres of oil injected subcutaneously |                                      |        |        |        |
| January 23, 1928..... | 14.4  | 66                                   | 85     | 83     | 85     |
| January 25, 1928..... | 14.2  | 70                                   | 108    | 71     | 72     |
| January 27, 1928..... | 14.2  | 73                                   | 105    | 81     | 70     |
| February 2, 1928..... | Animal was killed this date   |                                      |        |        |        |

Liver (Pathologist's Report. Dr. Warthin): "Active interlobar hepatitis, type of atrophic cirrhosis. Slight fatty infiltration, but well-marked fatty degenerative infiltration of central portions of lobules."

chloroform and phosphorus poisoning to give results similar to those obtained in Dog No. 52. Three other dogs treated in a similar manner reacted with curves as did Dog No. 52.



*Comment.*—No definite conclusions can be drawn from experiments so short and incomplete, but the results are suggestive. Other factors producing alterations in rate of sugar absorption such as prolonged fasting and damage to the pancreas or pituitary gland were not present in the animals on whom operation was done. The relatively small amount of liver removed and the quick regeneration made possible only slight and transient variations in glucose tolerance, but when the effect was cumulative as in Tables I and II, the blood sugar curves assumed with each increment of damage an accentuation of certain features that may be characteristic. The fall in the

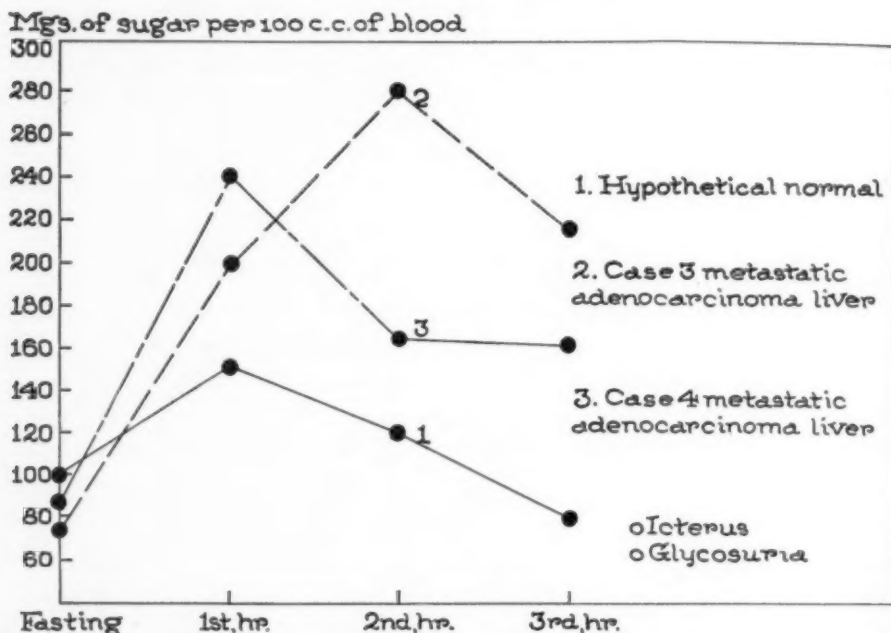


FIG. 3.—Graphic representation of cases 3 and 4. Marked retardation in second and third hour with low fasting blood sugar.

fasting level with increased damage seems fairly constant. The high reading in the second hour and in the third hour when more liver was removed occurred regularly. It is suggested that this disturbance is due to a lessened ability of the liver to form glycogen, so that it has less to convert into glucose during fasting periods when the animal is deprived of an exogenous supply and less capacity for removing glucose from the portal blood following the ingestion of glucose. While the curves obtained with glucose are more labile than those obtained with levulose, the variations from a known normal are distinct and easily seen. The relation of the fasting level to the level at the first hour when considered alone seems to have no significance as there is often a marked variation in the height of the first hour level in normal animals and in man. This relation has been suggested as a criterion of liver damage, but varies too much to be significant.

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TABLE VI  
*Glucose Tolerance Tests on Patients with Intrinsic Hepatic Lesions*

| Case No. | Age | Clinical diagnosis                           | Icterus | Blood sugar determinations |     |     |     | Glycosuria during test | Remarks                                    |
|----------|-----|--|---------|----------------------------|-----|-----|-----|------------------------|--|
|          |     |  |         | Fasting                    | 1°  | 2°  | 3°  |                        |  |
| 1        | 19  | Subacute yellow atrophy. Arsenical hepatitis | No      | 60                         | 140 | 142 | 156 | None                   | Ascites                                    |
|          |     | Same. Two weeks later                        | No      | 65                         | 172 | 167 | 133 | None                   | Ascites. Recovery                          |
| 2        | 16  | Syphilis. Luetic hepatitis                   | Mod.    | 90                         | 189 | 186 | 145 | None                   | Recovery. Test nine days after entrance    |
| 3        | 32  | Ca. of stomach. Metastases in liver          | No      | 88                         | 198 | 281 | 216 | None                   | Autopsy                                    |
| 4        | 51  | Ca. of stomach. Massive metastases in liver  | No      | 74                         | 240 | 164 | 162 | None                   | Biopsy. Test seven days post-operative     |
| 5        | 34  | Metastatic ca. of liver                      | No      | 93                         | 186 | 174 | 159 | None                   | Operation                                  |
| 6        | 66  | Ca. of liver                                 | No      | 83                         | 160 | 161 | 137 | None                   | No autopsy                                 |
| 7        | 68  | Hepatic cirrhosis                            | No      | 90                         | 161 | 215 | 198 | None                   | Died of pneumonia one month later. Ascites |
| 8        | 50  | Hepatic cirrhosis                            | No      | 76                         | 154 | 152 | 102 | None                   | Operation. Ascites                         |
| 9        | 58  | Hepatic cirrhosis                            | No      | 90                         | 175 | 178 | 180 | None                   | Autopsy                                    |
| 10       | 55  | Hepatic cirrhosis                            | No      | 90                         | 220 | 290 | 260 | Slt. 2°                | Autopsy                                    |

*Clinical Observations.*—These studies were made on a series of patients with known disease involving the liver. The tests were conducted according to the standard methods. In Table VI are collected cases with known liver damage but without jaundice except one instance.

CASE I.—A girl, 19 years of age, had acute arsenical hepatitis with jaundice four weeks before entrance to the hospital. The jaundice cleared up but ascites appeared which was present during the time the tests were made. The first curve shows a low fasting level, the levels at the first and second hours are equal and the third hour is at a level higher than either of the first two hours showing a marked prolongation of the curve. A curve taken two weeks later shows a low fasting level, with first and second hours about equal, but a distinct drop in the level of the third hour.

CASE II.—A girl, sixteen years of age, with maculo-papular secondary syphilitic eruption, and a moderate jaundice thought to be due to secondary syphilitic involvement

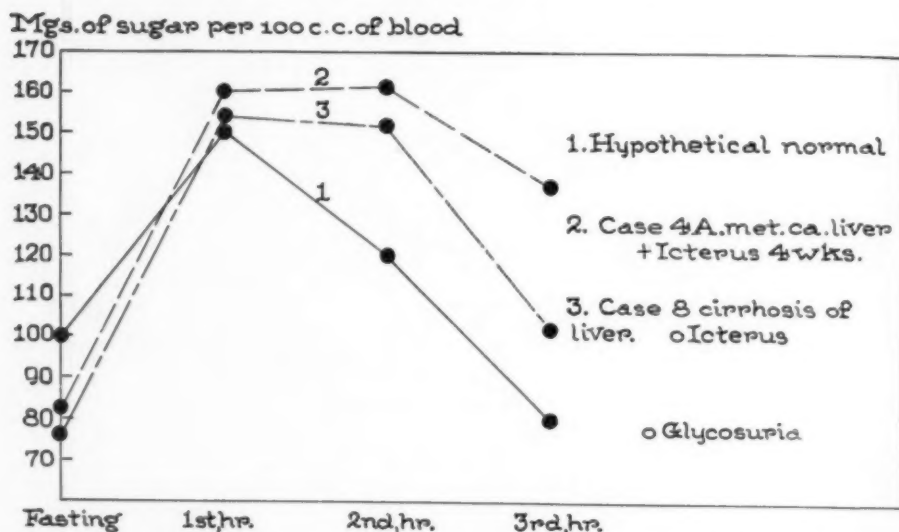


FIG. 4.—Graphic representation of cases 4a and 8. Marked retardation in second and third hours.

of the liver. The curve shows levels at first and second hours to be the same, giving a plateau top to the curve with a high third hour level.

CASES III to VI are patients with massive metastatic cancer of the liver. The fasting levels are lower than normal. All show a high second and third hour level in comparison with the level of the first hour. Case III in particular shows a curve that might be called diabetic in type were it not for the low fasting level.

CASES VII to X are examples of hepatic cirrhosis, of the portal type, in an advanced stage. The fasting levels are again slightly below normal and in Case VIII distinctly lower than normal. The level of the second hour is either equal to that of the first hour or higher, and three of them show a marked elevation at the third hour. All cases in this group had gross damage to the liver and all showed certain characteristic changes in the blood sugar curves.

In Table VII are grouped a variety of conditions causing jaundice. Cases 1a and 2a had acute catarrhal jaundice and both show sugar curves that are normal in every respect. This was to be expected since this condition is of short duration and no severe involvement of the liver is caused. Case 3a, a woman, forty-seven years of age, with moderate jaundice and pain over the liver two months after a course of five injections of arsphen-

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TABLE VII  
*Glucose Tolerance Tests on Patients with Lesions Causing Jaundice*

| Case No. | Age | Clinical diagnosis                    | Icterus               | Blood sugar determinations |     |     | Glycosuria during test | Remarks      |   |
|----------|-----|---------------------------------------|-----------------------|----------------------------|-----|-----|------------------------|--------------|---|
|          |     |                                       |                       | Fasting                    | 1°  | 2°  |                        |              | 3°  |
| 1a       | 21  | Acute catarrhal jaundice              | Marked 2 weeks        | 107                        | 156 | 120 | 97                     | None         | Recovery in two weeks                     |
| 2a       | 24  | Acute catarrhal jaundice              | Marked 3 weeks        | 110                        | 158 | 118 | 96                     | None         | Recovery in three weeks                   |
| 3a       | 47  | Active arsenical hepatitis            | Mod. 3 weeks          | 57                         | 208 | 91  | 53                     | Trace        | Recovery in seven weeks                   |
|          |     | Same—in two weeks                     | Marked                | 100                        | 256 | 87  | 63                     | Slight trace |   |
| 4a       | 39  | Luetic hepatitis                      | Yes—6 weeks           | 68                         | 85  | 78  | 65                     | None         |   |
| 5a       | 50  | Stone-common duct                     | Intermittent 6 months | 88                         | 241 | 189 | 79                     | Slight trace | Before operation                          |
|          |     | Same                                  |                       | 85                         | 153 | 117 | 80                     | None         | One week after choledochostomy            |
|          |     | Same                                  |                       | 80                         | 156 | 110 | 95                     | None         | Two weeks after choledochostomy           |
|          |     | Same                                  |                       | 81                         | 159 | 92  | 83                     | None         | Three weeks after choledochostomy         |
| 6a       | 49  | Cholecholethiasis                     | Intermittent 3 months | 60                         | 185 | 187 | 187                    | Yes          | Operation cholecystectomy-choledochostomy |
|          |     | Same                                  | No                    | 85                         | 164 | 148 | 140                    | None         | Three weeks after operation. Wound healed |
| 7a       | 59  | Cholecystitis                         | Intermittent 2 months | 96                         | 156 | 110 | 94                     |              | Operation                                 |
| 8a       | 75  | Ca. common duct. Metastases in liver  | Marked 4 months       | 76                         | 101 | 114 | 138                    | None         | Died two weeks. Autopsy.                  |
| 9a       | 65  | Ca. head of pancreas                  | Marked 2 months       | 66                         | 145 | 240 | 65                     | None         | Before operation                          |
|          |     | Same                                  | No                    | 81                         | 211 | 117 | 114                    | None         | Two weeks after cholecystoduodenostomy    |
| 10a      | 65  | Ca. head of pancreas                  | Marked 2 months       | 79                         | 120 | 128 | 78                     | None         | Before operation                          |
|          |     | Same                                  | No                    | 89                         | 161 | 130 | 93                     | None         | Ten weeks after cholecystogastrotomy      |
| 11a      | 61  | Ca. head of pancreas                  | Marked 6 weeks        | 101                        | 210 | 215 | 226                    | None         | Before operation                          |
|          |     | Same                                  | No                    | 110                        | 160 | 128 | 90                     | None         | One month after cholecystogastrotomy      |
| 12a      | 54  | Ca. head of pancreas                  | Yes—3 months          | 75                         | 135 | 111 | 71                     | None         | Autopsy                                   |
| 13a      | 58  | Ca. gall-bladder. Metastases in liver | Yes—2 months          | 90                         | 215 | 220 | 158                    | None         | Operation                                 |
| 14a      | 34  | Metastatic ca. of liver               | Marked 4 weeks        | 83                         | 160 | 161 | 137                    |              | Autopsy                                   |

mine. She lost all symptoms in seven weeks and was regarded as a mild case of arsenical hepatitis. The first curve is not grossly abnormal except for the very low fasting level, the curve being of the emotional type. A second test taken two weeks later after some clinical improvement was similar to the first except for a rise in the fasting level to normal. Case 4a was a patient with primary syphilis who developed jaundice following four injections of arsphenamine. His curve shows a low fasting sugar and a very low level for the entire curve. Several observations made during his convalescence showed a gradual rise in the entire curve to a low normal level.

Cases 5a to 7a were patients with jaundice due to a stone associated with mild infection in whom it was difficult to evaluate the amount of liver damage present. Case 5a had intermittent jaundice for six months and the curve before drainage of the common bile duct shows a low fasting level with definite elevation at the second hour. Following operation the curves gradually assume a normal contour except for persistence of the low fasting level. Case 6a with jaundice of only three months duration shows the

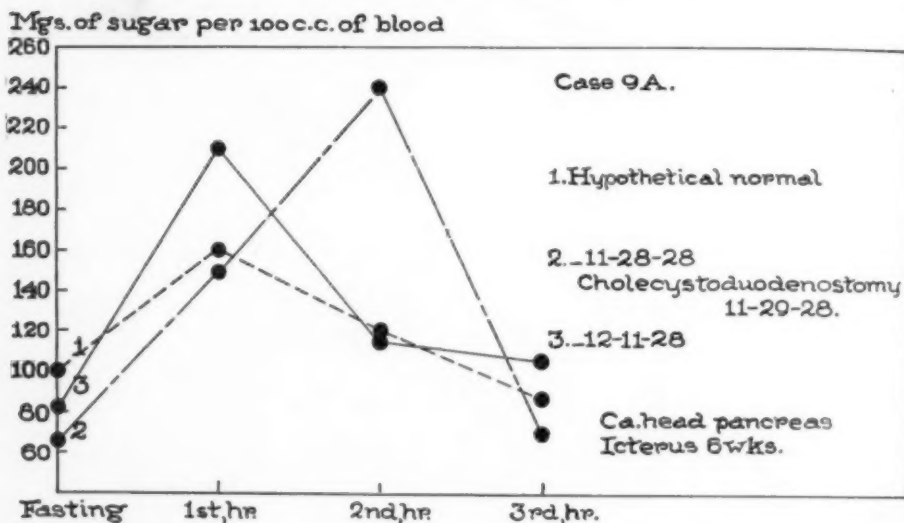


FIG. 5.—Graphic representation of Case 9a. Shows tendency of curve to assume normal shape after drainage of biliary tract.

same characteristics to a more marked degree. The fasting level is very low and the second and third hour levels are as high as the first. Three weeks after operation the curve is assuming a normal character except for the slight prolongation at the second and third hour. Case 7a, less severely sick, has a normal curve. Case 8a, a far advanced carcinoma of the common duct with massive liver metastases and jaundice of four months' duration, shows a very low fasting level with a progressive rise in the curve with each hour. Cases 13a and 14a are similar and show a slightly lowered fasting sugar with high second and third hour level. Cases 9a to 12a are patients with complete obstructive jaundice due to carcinoma of the head of the pancreas. Three of them show a very low fasting sugar. The curve of Case 12a is otherwise normal. Cases 9a, 10a, and 11a show levels at the second hour that are as high or higher than the level of the first hour. It might be said that these abnormalities were due to involvement of the pancreas by the carcinoma but in each of these patients internal drainage was done with a subsequent restoration of the curves to normal.

These observations on patients with jaundice do not give the same regularity of response in characteristic alterations of the glucose tolerance curves



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as did the patients with gross demonstrable damage of the liver. Obstructive jaundice alone may cause these changes or it may not. We have not found any measurable difference in reaction with relation to duration of jaundice and there must be great individual variations in other factors producing liver damage, such as infection, obstruction, and the length of time these factors have been at work. The three cases of obstructive jaundice that showed abnormal curves which returned to normal following relief of obstruction, seem to indicate a lowering of the glycogenetic function of the liver by jaundice of the obstructive sort.

### SUMMARY

We believe that injury to the liver shows a disturbance of carbohydrate metabolism in two forms. First, the glucose tolerance curve tends to the diabetic type; second, the fasting blood sugar is low and this second feature thus makes it possible to distinguish the disturbance of carbohydrate metabolism from that due to diabetes. In the presence of glycosuria a low blood fasting sugar level indicates that the patient is not suffering from diabetes and strongly suggests an abnormal liver.

### BIBLIOGRAPHY

- <sup>1</sup> Strauss, H.: Zur Funktionsprüfung der Leber. *Deutsch. Med. Woch.*, vol. xxvii, p. 757, 1901.
- <sup>2</sup> Rountree, L. G., Hurwitz, S. H., and Bloomfield, A. L.: Studies in Liver Function. *Trans. Ass. Amer. Phys.*, vol. xxix, p. 586, 1914.
- <sup>3</sup> Greene, C. G., Snell, A. M., and Walters, W.: Diseases of the Liver. 1. A Survey of Tests for Hepatic Function. *Arch. Int. Med.*, vol. xxxvi, p. 248, 1925.
- <sup>4</sup> Spence, J. C., and Brett, P. C.: The Use of Levulose as a Test for Hepatic Inefficiency. *Lancet*, vol. ii, p. 1362, 1921.
- <sup>5</sup> Bodansky, M.: Fructose, Glucose, Galactose Tolerance in Dogs. *J. Biol. Chem.*, vol. lvi, p. 387, 1923.
- <sup>6</sup> Bodansky, M.: The Effect of Chloroform and Phosphorus Poisoning on Carbohydrate Tolerance. *J. Biol. Chem.*, vol. lviii, p. 515, 1923.
- <sup>7</sup> Frank, E., and Isaac, S.: Ueber das Wesen des Gestörten Stoffwechsels bei der Phosphorvergiftung. *Arch. f. Exper. Path. u. Pharmacol.*, vol. lxiv, p. 274, 1911.
- <sup>8</sup> Williamson, C. S., and Mann, F. C.: Studies on the Physiology of Liver. V. The Hepatic Factor in Chloroform and Phosphorus Poisoning. *Am. Jour. Physiol.*, vol. lxxv, p. 267, 1923.
- <sup>9</sup> Izume, S., and Lewis, H. B.: The Influence of Hydrazin and Its Derivatives on Metabolism. *Jour. Biol. Chem.*, vol. lxxi, p. 51, 1926.
- <sup>10</sup> Mann, F. C.: The Effects of Complete and of Partial Removal of the Liver. *Medicine*, vol. vi, p. 419, 1927. (Complete bibliography.)
- <sup>11</sup> Mann, F. C., and Bollman, J. L.: Liver Function Tests. *Arch. Path. and Lab. Med.*, vol. i, p. 681, 1926.
- <sup>12</sup> Fishback, F. C.: Regeneration of Liver. *Proc. Staff Meetings of Mayo Clinic*, vol. iii, No. 49, p. 363, 1928.

## MEMOIRS

THOMAS W. HUNTINGTON, M.D.

1849-1929

IN THE passing of Doctor Huntington (April 19, 1929), California has lost another of her commanding figures—surgeon and citizen. He is the last of that group of remarkable men who, in this community at least, lived through the transition from septic to aseptic surgery.

Born in Rockford, Illinois, January 16, 1849, he received his bachelor's degree in the University of Vermont in 1871; his medical degree from Harvard in 1876. Not long thereafter he came West, became the surgeon of the Central Pacific in Wells, Nevada, and later, from 1885 to 1899, was the Chief Surgeon of the Central Pacific, and afterward of the Southern Pacific Hospital in Sacramento.

During this period he did much of his best work, and some of us, as medical students, remember hearing of a surgeon in Sacramento, who removed an inflamed appendix on the diagnosis of appendicitis. This was the first operation for appendicitis done in California. It was about 1890, at a time when in our medical curriculum the word appendicitis was not once heard.

In 1899, Doctor Huntington was made Professor of Clinical Surgery in the University of California, and moved to San Francisco, where he resided ever since. He occupied the Chair of Surgery until the reorganization of the medical faculty of the University of California in 1912. In 1910, he became Chief Surgeon of the Western Pacific Railroad, which position he held until his death.

Doctor Huntington, during his middle life, carried on an extensive practice in operative surgery; bold, but not rash, a surgeon of excellent judgment, who perhaps more than any other in this community, in his generation, kept up with the advances in surgical science and art. His experience in the treatment of fractures and of tumors was especially great. His contributions to surgical literature consisted chiefly of numerous reports of clinical cases characterized by careful observation and conscientious effort—in short, sound surgery. A fluent and impressive speaker, he was often called upon for formal addresses. In later life, many honors came to him: in 1913, the degree of Doctor of Laws, from his University of Vermont; in 1917, he was sent as a member of an important commission under the Red Cross to Italy; he was a Lieutenant of the Medical Reserve Corps of the United States Army, and during the World War, organized a local faculty under authority of the Surgeon-General for the instruction of reserve medical officers. He was elected Fellow of the American Surgical Association in 1901. He was president in 1917.

His wife was Miss Harriet O. Pearson, of Wells, Nevada, who, with a son and daughter, survives him. The son, Thomas W. Huntington, Jr., is

## MEMOIRS

living in Capri, Italy, engaged in literary pursuits, and the daughter, Miss Emily H. Huntington, is instructor in Economics in the University of California.

At the age of eighty, Doctor Huntington was in full mental and unusual physical vigor—tall, slender, dignified; he promised to enjoy many more years of useful activity. His death, following a serious surgical operation, came as a shock to his many personal and professional friends.

EMMET RIXFORD

## DR. CLARENCE LESLIE STARR

1868-1928

THE death of DR. CLARENCE LESLIE STARR came with startling suddenness. A few of his intimate friends knew of his serious illness, but no one thought the end was near. In fact, his medical attendants hoped that after a



DR. CLARENCE LESLIE STARR

few months' rest he might be able to resume work. Forty-eight hours before his death, symptoms suddenly appeared which indicated that a fatal issue was inevitable and he succumbed to the final attack of angina on the evening of Christmas Day.

Doctor Starr was born at Georgetown, Ontario, on July 1, 1868. He was a distinguished graduate in medicine of the University of Toronto and a member of the teaching staff for thirty years. In 1921 he became the first full-time Professor of Surgery, and, at the same time was appointed Surgeon-in-Chief to the Toronto General Hospital. Previously he had been Chief Surgeon in the Hospital for Sick Children. On his assuming the duties of the Chair, he completely reorganized the

Department of Surgery. The department under his direction was recognized not only within the University as thoroughly efficient, but many distinguished visitors from various parts of the world were so impressed that they expressed their admiration of his achievement in no unstinted fashion. In 1926 he was invited to Harvard University where he temporarily occupied the Chair of Surgery, and, within the last few weeks, he was asked to occupy a

## MEMOIRS

similar position in St. Bartholomew's Hospital, London. He had hoped to spend a few weeks there in that capacity during the summer of 1929.

During the war he rendered most valuable service both overseas and at home. With the rank of Lieutenant-Colonel he was Surgeon-in-Chief in a Special Hospital at Ramsgate, England, and later exhibited splendid organizing ability in connection with similar work at the Christie Street Hospital, Toronto.

He was a Fellow of the American Surgical Association and Vice-President of that body at the time of his death. He was also a Past-President of the American Orthopædic Association and an Associate Member of the British Orthopædic Association. McMaster University conferred on him the degree of LL.D. *honoris causa*.

He was a most popular colleague, beloved and respected by all his associates. Surviving him are his wife and four daughters. One brother, also a member of the medical profession, lives in Corning, N. Y., and a sister lives in Brooklin, Ont.

A. PRIMROSE



## RICHARD WALKER BOLLING, M.D.

1882-1929

DR. RICHARD WALKER BOLLING was born in Huntsville, Alabama, September 14, 1882, and died in New York, April 6, 1929, of septic pneumonia, after an illness of five days.

He was of English Colonial stock, a member of a distinguished family.



RICHARD WALKER BOLLING, M. D.

In the Virginia Historical Society there is a complete collection of family portraits loaned by Mr. Richard Bolling, of Richmond, representing every generation of Bollings from Robert, the first to come to America. Bolling Hall, Bolling Island, and Bollingbrook are among the historic Virginia homes.

Doctor Bolling's early education was received at day school in Huntsville, and at Mr. Abbott's School, near Charlottesville, Va. From 1900 to 1905 he was at the University of Virginia, combining Academic and Medical courses, and graduated from the Department of Medicine.

He served as interne in the New York Hospital, St. Mary's Hospital for Children, and the Lying-In Hospital.

During the war he enlisted with the New York Hospital Unit in May, 1917, and served with the French at Chateau Anel with Mobile Hospital No. 2, and later at the New York Hospital Base at Chateauroux. He was demobilized March 30, 1919, with the rank of major.

He was appointed Associate Attending Surgeon to St. Luke's Hospital, in New York, in 1924, and Attending Surgeon in 1927. He was also Attending Surgeon to the Babies Hospital, and Consulting Surgeon to Stamford

## MEMOIRS

Hospital, Flushing Hospital, New Rochelle Hospital, New York Nursery and Child's Hospital, and St. Vincent's Nursery and Babies Hospital of Montclair, N. J.

During the last six years he published a number of interesting papers surgical diseases of children, a book on "The Surgery of Childhood," and a monograph in Lewis's *Surgery* on "Congenital Hypertrophic Pyloric Stenosis."

During the years in which he was doing active surgical work he distinguished himself in an outstanding manner by soundness of judgment and by an admirable sureness of technic. His straightforward character and a certain inborn integrity inspired confidence in all those he cared for and won the admiration, respect and affection of those intimately associated with him. His death, in the full swing of his personal activities, leaves behind a feeling not only of deep sorrow but of irreparable loss.

WALTON MARTIN

### SIR ANTHONY BOWLBY, HONORARY FELLOW

SIR ANTHONY ALFRED BOWLBY, seventy-three years of age, surgeon-in-ordinary to King George, died at his home in London, April 9, 1929, from pneumonia.

Anthony Alfred Bowlby was born May 10, 1855; the son of T. W. Bowlby and Maria Bridget Mostyn. He was educated at Durham School and St. Bartholomew's Hospital, to which he was consulting surgeon at the time of his death.

Bowlby was created a knight in 1911 and a baronet in 1923. He was president of the Royal College of Surgeons from 1920 to 1923. He was the author of many works on surgical subjects.

During the World War he held the rank of major-general.

Sir Anthony was consulting surgeon in the British forces in France during the World War and was the physician who rendered first aid to King George when his horse threw him in 1915.